PLANT and ANIMAL CHILDREN and How They Grow

TORELLE

D. C. HEATH & CO.

PLANT AND ANIMAL CHILDREN

HOW THEY GROW

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PREFACE

This book attempts to express in simple language the essential facts and principles of growth and development in plant and animal life and to show the relation of these facts and principles to human life. It is written especially for children. It aims to make clear the ideas of evolution, heredity, variation, effect of environment, and the evolution of sex, without once mentioning these names. In this it is a departure from that tradition which has held that such ideas are the exclusive prerogative of the college-bred. The author has demonstrated by practical tests that children are not only greatly interested in the study of plant and animal life when this study is progressive and related to human life and its problems, but that they are also able to comprehend the subject-matter of botany and zoölogy when this is expressed in language suitable to their comprehension.

The need for instruction of the young in morals is receiving widespread recognition. Morals have their foundation in life phenomena and can be taught adequately only with reference to these

phenomena. A survey of the whole range of plant and animal life teaches the child inductively that all life, and therefore also human life, is governed by fixed laws, and that ignorance or transgression of these brings its certain penalty.

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PLANT AND ANIMAL CHILDREN

CHAPTER I

THE APPLE, THE OAK, AND THE GRASSES

When you were little and long before you first went to school, did you not sometimes wonder where all the grasses came from; why an apple has seeds; and how an oak can come from an acorn? Even now it would puzzle you to answer these questions, for they are more difficult than 7 times 9, and it has taken wise people a long time to discover the correct answers.

Where do you think the answers were found? All written down in a big book? Yes, that is true; but not in a book like the one in your hand, but in a Great Book that Nature has written, and that is always open for those who have learned to read it. The leaves of Nature's Book are the earth, and the sea, and the sky. The letters are stars and suns, waves and rocks, flowers and trees, and all living things everywhere.

For a long time people tried most to learn about the stars, and the sun, and things that are far away from the earth. And as people usually learn most

about the things they study most, so people long ago knew more about the stars than about the living things around them.

Perhaps one reason that the living things received so little attention was because many of the people believed that all living things were put upon the earth by huge beings, called gods, who lived somewhere out of sight on the tops of high mountains, and who occasionally came down to visit the places where men lived. They thought that these gods could not only make the grass grow, but could stop its growth, if they pleased; that they could destroy the apples on the trees and pull up the oaks by their roots.

Of course, no one believes such things now, for since the time that your great-great-great-grandmother was a little girl, many people have been studying the living things on the earth, and wonderful things have been learned — things that every boy and girl in school and out of school ought to know. Learned people know now that a plant is a living thing like a boy or a girl. A plant needs food, and water, and air, and a place in which to grow, just as does a boy or girl. A plant becomes sick if the conditions of its life are not favorable, and it responds to care by becoming large, more beautiful, and more perfect in its growth, just as boys and girls do. Every plant was once a baby plant, too, and that is precisely what is so puzzling: Where do the plant babies come from and how do they grow?

Where the Apples Come From

Everybody knows that apples are used to eat, and that the seeds are thrown away or destroyed. Then why has an apple seeds?

If an apple is cut across its middle, one sees distinctly that it is made up of several parts. On the outside is a tough, oily, leathery covering; then comes a thick, white, pulpy substance which is pleasant to the taste and which people eat; and lastly, in the centre, are five little chambers crowded close together, their walls made of a horny, shiny, yellowish substance. The pulp covers

Fig. 1. American Crab Apples

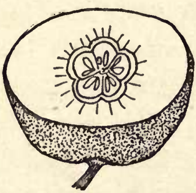


Fig. 2. An Apple cut in two Crosswise

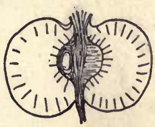


Fig. 3. An Apple cut in two from Top to Bottom

these chambers to a depth of one, two, or more inches.

Inside each chamber are two little brown seeds, nearly oval in shape. The form and size of the seeds, as well as the shape and size of the chambers, can be seen very well also by cutting the apple in two from top to bottom. The seed is very much smaller than that of the acorn, but its parts are quite similar. It has a thin brown covering under which are two seed-leaves. Attached to these seed-leaves is a little baby apple tree.

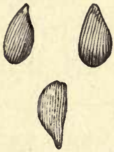


FIG. 4. APPLE SEEDS

FIG. 5. AN APPLE SEED WHICH SHOWS ONE SEED-LEAF AND ITS COVERINGS

The seed-leaves, full of food for the little one's use; the horny chamber walls; the thick, juicy pulp; the leathery skin—what do you think all these were made for? For the use and protection of the little baby apple trees and not at all for us! All summer long the apple tree works and works, every day and all day long, to store up food for the little ones inside the seeds.

FIG. 6. THE BABY APPLE TREE AND THE TUBES IN THE SEED-LEAF WHICH BRING IT NOURISHMENT

Some people think that the apples remain green and sour to the taste in summer because the greenness and sourness prevent people and animals from eating them and so destroying the seeds in which the little baby trees are not yet big

enough to grow by themselves if thrown upon the ground. A baby apple tree can never become a big tree as long as it remains in the apple, of course. It must get out where it can have air, and sunlight, and water, and more food than that provided by the tree and the seed-leaves. So, when the baby trees inside the seeds are full-grown, the pulp becomes soft and sweet to the taste, the apples turn red or yellow, and are then picked by animals and by human beings to be carried off, sometimes for long distances, and so scattered over the world.

Since it is the pulp, not the seeds, which is eaten, the seeds fall upon the ground, and here they get just what they need to help them to grow. The part of the apple that people eat is not necessary for the growth of the baby tree after the apple is ripe. It is in the summer before the seeds are full-grown that the pulp is necessary to the baby trees; but if no one eats it, this too can be used by the little tree during its early growth.

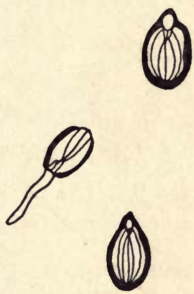


Fig. 7. Three Baby Apple Trees Beginning to Grow

Once on the ground, the covering opens at one end and the root and stem-bud come out. The root turns and grows into the ground, the stem-bud becomes erect and grows upward. Soon the little plant can make its own food, and it uses all its time and power to grow big

and strong. But it takes three, four, or more years before it is ready to bear apples. And when it does bear apples, these may be very unlike the apple in which the tree grew when it was a baby plant. If you were to plant a seed of the Ben Davis or of the Northern Spy apple, the tree which grows from this seed will not bear Ben Davis or Northern Spy apples, but apples which are much smaller in size and different in appearance.

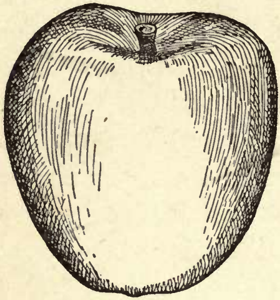


FIG. 8. BEN DAVIS APPLE

In order to understand how this can be, we must learn how the baby apple tree gets into the seed, and how the seed gets into the apple.

Of course you have seen an apple tree in bloom, so you know what a beautiful sight it is, and how fragrant the air is all about the tree. But the apple tree does not seem to care that we enjoy its beauty and fragrance. Its beauty and fragrance are of distinct use to the apple tree in doing its work in the world. This work is of two kinds. First, to make food for itself, and grow big, and strong, and healthful, and beautiful; and then, to bear flowers and fruit. So when it has become quite big it puts out little rounded buds in clusters of two or more on its new branches. These buds grow for nearly a year, and then

when the winter is over and the air has become soft and warm, they open into beautiful pink-and-white flowers.

Each flower is made up of a green cup-like part, called the calyx; of five pink-and-white delicate leaves, called petals; of twenty or more slender, erect threads, each with a yellowish sac at the end. These slender threads are called stamens, and in each sac are a great many small yellow pollen-grains—more than you can count. The stamens are arranged in rows and, like the petals, are attached to the calyx. Within the circle formed by the stamens are three green tubes which unite below to form a small, green, flask-shaped body.

FIG. 9. APPLE BLOSSOMS

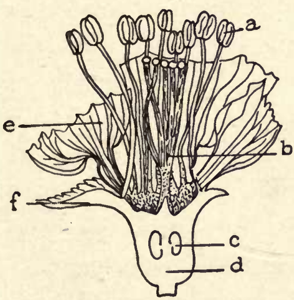


FIG. 10. THE PARTS OF AN APPLE BLOSSOM
a. stamen; *b*. pistil; *c*. ovary; *d*. calyx; *e*. petal; *f*. sepal.

The lower, broad part of the flask-shaped body is called the ovary, because it contains *ova* or eggs. The ovary, together with its tubes, is called the pistil. The stamens and pistil are the most important parts of the flower, because each contains a tiny bit of living substance, and when these two tiny bits are united they will grow into a new apple tree.

FIG. 11. POLLEN ESCAPING FROM THE POLLEN SACS

But a finer, stronger, and more beautiful new tree will grow, if living substance from two different flowers, or from two different trees, unites. So the petals of the flowers are brightly colored and bear, near their lower parts, little drops of a sweet fluid, called nectar. Bees see the bright colors of the petals and come to get the nectar for the honey which they make. In getting the nectar they must creep past the sacs on the stamens which bear the pollen, and so the pollen-grains, which are like a fine yellow dust, become entangled in the hairs which cover the body of the bee.

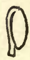


FIG. 12. AN EGG FROM THE OVARY OF THE APPLE BLOSSOM

FIG. 13. BEE VISITING A FLOWER

When the bee has taken the nectar from one flower, it flies to another, and here it leaves some of its load of pollen on the pistil of this flower. The top of the

pistil is covered with a gummy substance which holds the pollen-grains fast until one of these grains has put out a little tube which grows down into the flask-shaped ovary, carrying with it the living substance of the pollen-grain, which is called a sperm cell. The sperm cell unites with the living substance of an egg, and then the egg is ready to begin to grow into a new baby tree. Each egg of the ovary must unite with a sperm cell in a pollen-grain before a new little plant can grow.

FIG. 14. A POLLEN-GRAIN SENDING OUT A TUBE BEARING THE SPERM CELLS

As soon as the baby plant begins to grow, the tree sends up nourishment to it through tubes which pass into the flower from the tree, and whatever is not needed by the little plant is stored up in the seed-leaves which form about it. The walls of the ovary become firm and horny, the petals fall off, and the walls of the calyx thicken and grow around the ovary, the seed, and the little baby tree. It is this thickened calyx which forms the sweet, juicy part of the apple which we eat, the real purpose of which is to protect and nourish the baby plant in the seed.

The core of the apple is the ripened ovary, and each of the seeds contains a little plant which grew from the living substance in an egg and from the living substance in a pollen-grain. And this is the reason an apple has seeds. The apple tree not

only works to care for its own body, but to provide food for as many baby apple trees as it can.

Perhaps we are now ready to learn why the seed from a big apple like the Northern Spy does not grow into an apple tree which bears Northern Spy apples, but into a tree which bears apples very much smaller than these.

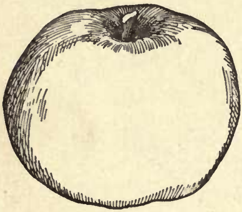


Fig. 15. Northern Spy Apple

Long ago, before Columbus discovered America, even before the pyramids in Egypt were built, there grew in southern Asia and Europe a tree which bore small apples. This tree grew wild in the woods among other trees. But some people found it good to eat, and also discovered that when the juice was pressed out of the apples and fermented, a pleasant drink was made. So, to have it near where the fruit could be picked as soon as it was ripe, some of the wild trees were moved from the woods to the gardens, where the soil was rich and carefully cultivated. The trees that were moved grew bigger and bore larger apples than the wild ones, and in time most people in Europe and Asia had apple trees in their orchards. When a large number of trees had been planted, the people began to discover that some trees bore better fruit than

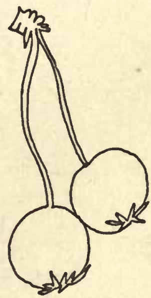


Fig. 16. European Wild Apples

others. So the trees that bore the finest fruit were selected to live, and the ones that bore poor fruit were cut down. For a long time only the finest trees were kept, until at last the trees in the orchard bore apples which were bigger and more pleasant to the taste than the apples of the wild trees.

Then some one discovered that if the pollen from the flowers of a Siberian crab apple tree were placed upon the pistils of the flowers of the common cultivated apple tree, a tree would grow which bore apples very much larger than either the common cultivated apple or the crab apple. So they took care to exchange the pollen of these trees, and in trying in various ways to improve these apples, most of our different kinds of cultivated apples have been grown.

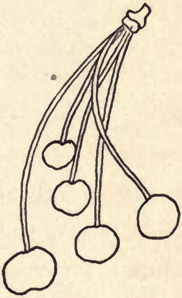


FIG. 17. SIBERIAN CRAB APPLES

If the seeds of these large cultivated apples are planted, the trees which spring from them will, in most cases, bear apples like the common cultivated apple, or the crab apple from which they came. To prevent this, gardeners do not plant such seeds; but they cut, instead, a branch from a tree that bears fine big apples, and join it to the root or stem of a common apple tree. This joining of one tree to another is called grafting, and the branch that has been grafted grows fast to the root or stem of the common tree, and lives with its life;

but it bears apples like the tree from which the grafted branch was taken. When we buy small

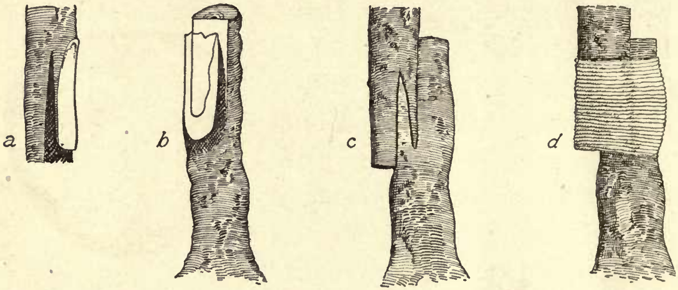


FIG. 18. THE WAY A BRANCH OF ONE TREE IS GRAFTED ON THE ROOT OF ANOTHER TREE

a. Branch cut ready to be put on the root. *b.* Root cut ready for the branch. *c.* Root and branch put together. *d.* Waxed cord wound around graft, and the work is finished.

apple trees of a gardener or nurseryman to plant in our gardens, these small trees are such grafts.

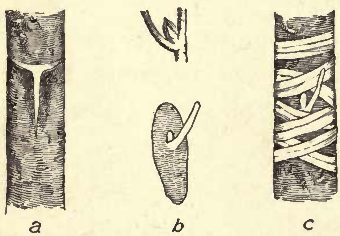


FIG. 19. THE WAY A BUD IS GRAFTED ON THE STEM OF ANOTHER TREE

a. T-shaped cut ready for the bud.
b. The bud attached to the bark.
c. The graft completed.

It sometimes happens that a seed of a big cultivated apple may grow into a tree that bears good fruit. There is one apple, called the Snow apple, whose seeds when planted grow into trees which also bear Snow apples. This apple tree grows in Canada, and in the northeastern United States. But it forms an exception to the rule.

Apple trees grow wild and cultivated in many parts of the world. When we go to Italy or Greece, we find apples growing there. India is thought to be the first home of the apple tree and it still grows there. In China and Japan the people prize the apple tree for its beautiful flowers, and in most countries of the world the apple is highly valued for food.

FIG. 20. SNOW APPLE

North America is said to be the best apple-growing region, and apple orchards can be seen throughout the country, extending from Nova Scotia to Virginia and west to Minnesota and Missouri. Apples also grow large and finely flavored in Oregon and California.

One kind of apple tree grows wild in North America, and has been planted in some English gardens. Apple trees grow best in clayey soil, or soil that is rich and moist.

The Hawthorn and the Mountain Ash are near relatives of the apple tree.

WHERE AN OAK TREE COMES FROM

Oak trees grow in many places both in the city and country; and wherever oak trees are, there we also find the very smallest of their children. Where would you look for the tiniest children of the oak?

On its arms, or branches, of course! And sure enough, on the upper side of the newest and most tender branches are little brown nuts, each in a close-fitting cup, and each brown nut is an oak baby's cradle. It is not called a cradle by most people, however, but an acorn; and an acorn grows for no other reason than to care for the oak baby until this can care for itself.

FIG. 21. A BRANCH OF WHITE OAK BEARING AN ACORN

In order to understand how this can be, we will gather a few of the acorns and look at them more closely. All oaks bear acorns, and the acorns of each kind differ in appearance from those of every other kind. In October showers of acorns usually fall from the trees. If we care to study them earlier, we can easily pick a few from the trees. If one is taken from the white oak we find that its cup is shallow and rough on the outside because it is made of many rather thick scales which are pressed close together. The cup is somewhat woolly and grayish-green in color.

FIG. 22. ACORN OF SWAMP OAK

The nut, which fits closely into the cup, is smooth and shiny. At the top is a pointed cap, darker in color than the rest of the nut. This can be taken off with the fingers, and then one sees that it covers a little circular hole which is the opening into the inside of the acorn. When the acorn is removed from the cup one finds the cup smooth within, and the nut is almost flat at the bottom where it was attached to the cup. This flat side is rough in points where little tubes have been broken off.

FIG. 23. ACORN OF BLACK JACK OAK

FIG. 24. EMPTY CUP OF WHITE OAK

These tubes connected the nut with the cup, and the cup with the tree, and carried nourishment to the nut while it was growing. For the acorn cannot make its own food. The tree makes its food and sends it up through these tubes. When the acorn is full-grown it does not need more food from the tree, so the tubes break off, and the acorn is ready to leave the tree.

FIG. 25. ACORN SHOWING THE POINTS WHERE THE TUBES CONNECTING IT WITH THE TREE HAVE BEEN BROKEN OFF

Let us split the outer covering of the acorn into two equal parts. The outer covering is hard and tough and has lines on it running from the top to the bottom. Inside of this hard covering is still another thin, papery one, which clings to a body inside, which is of the same shape as the hard covering, but which

feels firm and solid to the touch. This is the seed.

To be able to see just how the seed is related to the baby oak, it is well to place it in water for an hour or two, after which it will readily divide into two parts. If care is taken not to tear these parts, one finds that each is attached to a tiny white body which lies in a cavity formed by a slight depression in each. This body is the baby oak. The two parts of the seed are the so-called seed-leaves in which food is stored up for the little oak. The baby oak lies with its roots pointing upward or toward the pointed end of the seed, and its stem-bud pointing downward or toward the flat part of the seed. Little tubes lead from the seed-leaves to the baby oak to carry it food whenever this is needed.

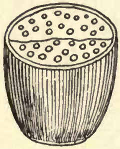


Fig. 26. An Acorn cut in two to show Thick and Thin Coverings and the Seed Leaves with the Tubes running through them

The acorns of the white oak become full-grown every autumn, and usually lie on the ground all winter, covered over by dead leaves and branches. Then when the spring rains come, the seed-leaves and the little oak between them begin to swell, the hard covering breaks open, and the little root grows out and turns downward into the earth. After the root has become two or three inches long, the stem-bud comes out

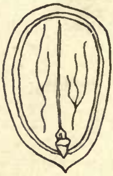


Fig. 27. The Baby Oak and one Seed-Leaf with its Coverings

from the seed-leaves also, and grows erect into the light and air. The seed-leaves never leave the acorn, but remain inside the hard covering. They give all the food they have stored up to the little root and the young stem-bud, and then they die and remain buried in the ground.

FIG. 28. ROOT AND STEM-BUD OF THE BABY OAK GROWING FROM THE ACORN

For a time the little oak has no real leaves, but has instead a few small, scattered scales, each with a small bud in its fold. But before the summer is over, from four to six leaves have formed, each on a small stalk. The little oak has a root from twelve to eighteen inches long, and its stem is not quite one half as tall. There are fine hairs over the stem and leaves, as well as on the roots. The tip of each little root is protected by a cap called a root-cap, because it protects the root as it pushes its way among rocks and sand.

FIG. 29. SCALE LEAVES ON THE STEM OF THE LITTLE OAK

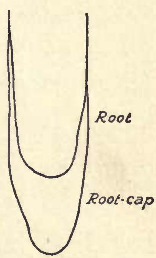


FIG. 30. THE ROOT-CAP

In the spring of the second year the roots have grown stouter and larger and have become covered with cork. Little

branches grow out from the stem, which also become covered with cork. The young tree is now called a seedling, and as it grows bigger it also gains more parts until at last it is a full-grown tree.

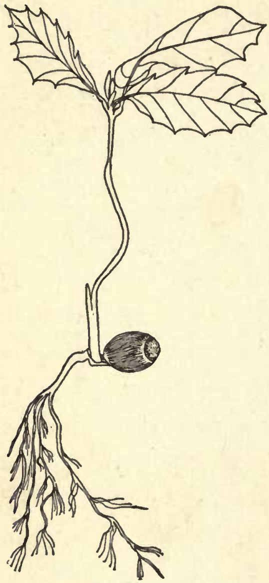


FIG. 31. A SEEDLING OAK

Now you will wish to know how the baby oak got into its cradle where it was wedged in so closely between the two seed-leaves and yet never harmed in the least by them.

Not every oak tree bears acorns. Only on trees which have lived many years will acorns be found. Sometimes it takes sixty or more years for an oak to get ready to give of its substance to little baby oaks, and so only really grown-up trees bear acorns. If you look at such a grown-up tree in May, before the leaves have become very big, you will see on the outer and topmost twigs soft, reddish, fuzzy cords which hang down in bunches. These cords are called catkins or

FIG. 32. A FLOWERING BRANCH OF THE WHITE OAK

spikes, and each catkin contains more than a dozen tiny flowers.

Each flower consists of from five to seven leaf-like lobes, which enclose from five to twelve slender threads, each with a sac at its upper end. These thread-like bodies are the stamens, and in the sacs very small roundish grains, called pollen, grow. In each pollen-grain is a tiny plant, which carries a small bit of living substance called a sperm. The living substance in the sperm has been set aside by the tree for the growth of a new oak tree.

FIG. 33. A STAMINATE FLOWER OF THE WHITE OAK

FIG. 34. A PISTILLATE FLOWER OF THE WHITE OAK

But the sperm alone can never grow into the new oak. So another kind of flower grows on the same twigs that bear the catkins. There are not so many of these flowers on each tree, and they grow in low, small clusters. Each flower in the cluster differs, too, from those which grow in the catkins. Instead of having stamens with pollen-grains, there are bottle-shaped structures, each of which contains a plant which carries an egg. Now an egg, like a sperm, contains a bit of living substance which has been set aside to form a new oak.

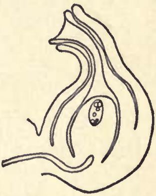


FIG. 35. AN EGG IN ITS SAC IN THE OVARY OF THE FLOWER

This living substance will not by itself grow into

an oak; but the living substance of the egg and of the sperm when united together grows into a new oak. So, when the plant inside the pollen-grain is full-grown, the pollen falls off and the wind carries it to the opening of the flask-shaped structure, which is called an ovary because it contains the ovum or egg. There is a gummy substance at the top of the ovary, and this holds the pollen-grain fast until the little plant inside has carried its living substance down to the living substance of the egg.

When the living substance of the sperm and the living substance of the egg unite into one substance, this grows and changes in size and in form until a little baby oak like the one we found in the acorn has been formed. The walls of the ovary change into the coverings for the seed-leaves, and little leaves grow around the foot of the ovary which thicken and become pressed close together to form the cup in which the acorn stands. The little tubes which carried nourishment from the tree to the flowers continue to carry nourishment to the little baby oak, and much food is also stored about it to be used later.

This is the way a baby oak grows, and all the big oaks come from baby oaks.

There are about three hundred different kinds of oaks in the world, and about fifty different kinds in North America. Oaks live in places that are neither very hot nor very cold. In India, oaks live on the mountain slopes. Oaks do not live in

southern and central Africa or in Australia; but in other countries of the world some kind of oak is pretty certain to be found. One kind which grows in the south is called the Live Oak because its leaves do not fall in the autumn or winter. In China, Japan, and India, a certain silkworm feeds on the leaves of the oak. The bark of one kind of oak which thrives in Spain furnishes us most of the cork we use for stoppers for bottles. The wood of oaks is used for fuel, for making charcoal, and for lumber. Because the wood is so hard and firm, the oak is one of the most valuable timber trees.

Perhaps you would now like to know how a grown-up oak tree gets its food and drink and why the leaves are green in summer and turn red, yellow, and brown in autumn, and then fall off in winter? There are many wonderful things to learn about the life of a grown-up oak tree, but we will be able to understand these things better when we have learned how plants very much smaller and simpler than the oak tree live and get their food.

How the Grasses Grow

Very few grasses have bright or fragrant flowers, and most of them are so low and look so much alike that few boys and girls notice them much except to exclaim in the early spring, "See how green the grass is! How fast it grows! Mother, what *makes* the grass grow?"

And it is truly wonderful to see it creep about everywhere — by the roadside, over the hills, along rivers and streams, in the woods under the trees, or, standing erect and tall, it covers acres and acres of fields in the country, where it is one of the farmers' most important crops.

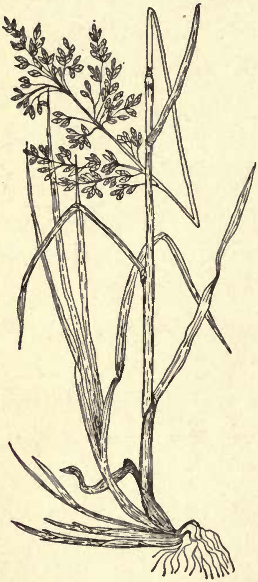


FIG. 36. A SINGLE PLANT OF JUNE GRASS

Perhaps you have seen a field of waving grass in June, when the shadows chased one another back and forth over it; and you have watched this play of sun and shade until you almost forgot the work you were sent to do, and you turned to look again as you walked away. Or perhaps you have gone into the orchard on a warm day and laid your aching head against the cool, soft grass under the old apple tree and pretended that the grass knew you were there and was glad. Perhaps you have never seen grass grow except in little patches about people's dooryards in the city. But even so, you love these brave, bright, cheerful little plants, that get right up again if you step on them.

Of course, all grasses do not behave alike, for there are more than three thousand different kinds.

Some of these grow in bunches, or a few plants here and there by themselves, like the bamboos of the south, or the oat grass of the north. Others grow in brooks, ditches, and swamps, or around the edges of ponds and lakes, and are called water grasses. The reed-grass, canary-grass, rice, and floating meadow grass are water grasses. Then there are the seaside grasses like the goose-grass, rush, salt grass, and mat-weed.

FIG. 37. WHEAT

The meadow or pasture grasses are the most important food for cattle, horses, and sheep, but the grain-grasses are the most valuable to man, for they furnish bread and other forms of food. Perhaps it is a surprise to you to learn that wheat, oats, barley, and corn are simply grasses which have been given great care and a good soil to grow in, because of their large seeds filled with starch and other food.

When wheat or rye first begins to grow, it looks very much like its cousins, the meadow and lawn grasses. But when the stems have grown, one readily sees that these are taller and stronger and the heads at their tops larger than in meadow grasses. The difference is so great that most people do not speak of wheat, oats, barley, rye, and corn as grasses at all, but as *grains* or *cereals*. Besides, there are so

many kinds of wheat, so many kinds of corn, of oats, of rye, and of barley that farmers and teachers must study much to learn which kinds are the best and which are poor, and how to improve all kinds so that people everywhere may be fed.

FIG. 38. ROOTS OF GRASS WITH SOIL PARTICLES CLINGING TO THE ROOT-HAIRS

But how do these, as well as the grasses of the pastures, the meadows, and the brook-side grow? How can the grass on our lawns grow up again, no matter how often it is cut? Let us take a plant of June grass or meadow grass, root and all, and examine it carefully to see what we can learn about it in this way. We find many roots of about the same size, and coming out from these a great many tiny root-hairs to which the soil clings.

Growing erect into the air is a green stem which bears leaves and flowers. The stem is hollow except at certain places that look like joints, and feel hard to the touch. These are called the *nodes*. The leaves are flat and clasp the stem at their lower part, forming a sheath which does not grow together, but is open at one side. The leaves do not grow from the same, but from opposite sides of the stem,

and they are very much longer than they are wide. Indeed, the leaves can grow many feet long if they are not cut off, and if they are cut, they grow out again. They can do this because they do not grow at the top but at the bottom, so that the tip of the grass blade is the oldest part of the blade.

Fig. 39. A Grass Blade showing the Ligule

If you look carefully at the grass blade on the inside and just above the place where it forms a sheath around the stem, you will see a small patch of light green, something like a new moon in shape. This is the *ligule*, and it is here that the growth of the leaf takes place. If this is cut off the grass blade cannot grow; but if the leaf is cut above this, it can grow out again and again. If the leaf of a grass turns brown or withers, it does not fall off as does the leaf of an apple tree, or of an oak; but it remains clinging to the stem on which it grew.

Fig. 40. A Flower of a Grass Plant

The flowers are found at the top of the stem, arranged in a cluster two or three inches long, called a spike. There may be a hundred or more flowers in each spike. None of the flowers have petals however; but we have already learned

that petals are not necessary to all flowers. A vessel called the pistil, for holding the plant which carries the eggs, and some sacs, called stamens, for holding the pollen-grain, are all that is necessary to a flower.

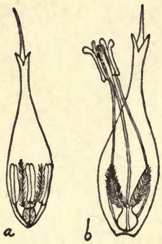


FIG. 41. TWO FLOWERS OF WHEAT

a. The flower before it is full-grown. *b*. The flower when it is full-grown.

In a grass flower, the stamen and pistils are protected by scale leaves, called *glumes*, which close until the eggs and the pollen-grains are ripe. In some grasses the scale leaves bear sharp, stiff bristles. Besides the leaves on the stem there are leaves around the stem, which come from its base or lower part, and these usually grow very tall, almost as tall as a man if they are not cut off during the summer.

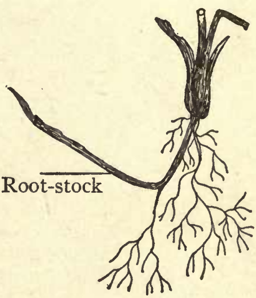


FIG. 42. THE ROOT-STOCK OF A GRASS PLANT

Growing from the roots and into the ground, instead of into the air, are other stems which are not green and bear no leaves. These stems are called root-stocks. From the root-stocks erect green stems grow into the air and bear leaves and flowers. Roots also grow in the ground, and in this way many grass plants grow from the root-stock of one plant, and the earth is bound together and held firm by the root-stocks and the roots. This is the

reason it is difficult to dig into grass-land, and to plow land where grass has grown for many years is not an easy undertaking.

Meadow grass blooms in June, and perhaps that is the reason it is also called June grass. But it has a number of other names according to the regions in which it grows. It is called Kentucky blue grass, blue grass, and spear grass. It grows in nearly all parts of North America, in England and many other parts of Europe, and in Asia and Australia.

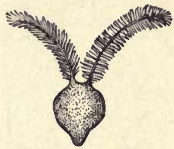


FIG. 43. THE PISTIL AND ITS TWO FEATHER-LIKE STYLES

When the pollen-grains and the eggs are ripe, the wind carries the pollen about and scatters it on the pistils in which the eggs are kept. At the top of the pistil are two feather-like bodies in which the pollen becomes entangled and held until one pollen-grain has grown out into a tube and so carried its living substance down to the egg and united with it. As soon as this is done, a new little grass plant forms, the walls of the pistil

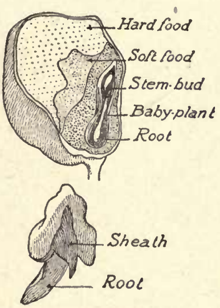


FIG. 44. THE BABY CORN PLANT AND THE BEGINNING OF ITS GROWTH

FIG. 45. THE WAY NEW GRASS PLANTS GROW FROM A ROOT-STOCK

become hard and firm to protect it, and the mother grass plant stores up nourishment around it.

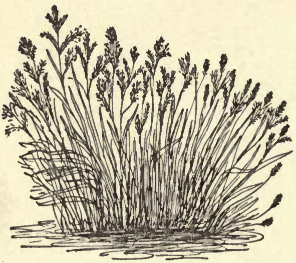


Fig. 46. All this Grass grew from one Little Seed

The little tubes that connected it with the mother grass plant break off, and the seed falls to the ground. After a time, when the seed has become wet by rain, the coverings open, and the little grass plant comes out only to send its roots into the ground and its stem into the air, and so add its body to the other grass plants growing about it. When once firmly rooted in the earth, its root-stocks grow and spread in the ground, and now the storms and frost may kill its leaves and stem, but the roots and the root-stocks are safe. So it remains quiet all winter under the snow. But when spring comes, it is all ready to grow again, and after the very first rain its stem and leaves come forth, green and fresh, to gladden the eyes of all who see it.

Fig. 47. Red Clover

If its leaves are eaten by sheep and cattle, it does not mind in the least, but grows new leaves instead

of the old; and as its root-stock grows, more and more grass plants grow up around it, all children of the tiny little plant in the seed that fell to the ground.

Fig. 48. A Single Flower from a Head of Clover

And this is the way the grass grows, and this is where all the grasses come from. Every seed holds a little grass plant, and when this grass plant grows, many other grass plants grow from the root-stock, or from the stem at its lowest part.

All grasses and grains grow in some such way as this. But many plants are called grasses which are not grasses at all. Clover is often seen on lawns and in fields, and the farmer raises it as feed for his cattle, horses, and sheep. But clover is not a grass; it is a plant related to the pea and the bean. Its flowers have colored petals and the seeds are borne in pods covered over by the calyx.

Fig. 49. Alfalfa

Alfalfa is a plant which belongs to the clover family, and it grows both in Europe and in America. It has been raised as food for cattle for many hundred years. In some places two or three crops a year are mowed. It can live in moist or in dry places, and thrives where many other grass plants seem unable to live.

In some places plants grow that look more like grasses than clovers do; but they are not so valuable for food for cattle because their stems are solid and tough; their leaves are sometimes harsh and not pleasant to the taste, and their seeds are not like the seeds of the grasses. These plants are called sedges, and they grow usually in wet or marshy ground and around the shores of lakes and rivers.

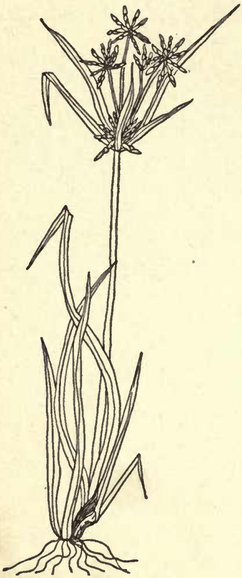


FIG. 50. A SEDGE

Sometimes grasses are called weeds, because a weed is a plant which grows where it is not wanted.

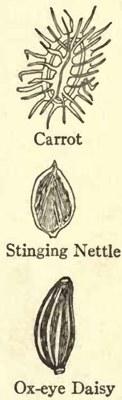


FIG. 51. SEEDS OF WEEDS

When a grass grows in the potato fields or among the cabbage and onions, it is called a weed. Otherwise, weeds are plants whose good qualities have not been discovered, but whose seeds are scattered by the winds far and wide and thus take up room and food that may be wanted for other plants whose uses are known, like grasses, grains, and garden vegetables. Some of the most trouble-

FIG. 52. THE LOCO WEED

some weeds and those which ought to be destroyed because of the harm they do to the farmer's crops, are the Ox-eye Daisy, the Canada Thistle, Ragweed, Burdock, Dodder, Russian Thistle, and the Loco Weed, which causes the death of cattle, horses, and sheep if they eat it.

CHAPTER II

GREEN THREAD-PLANTS AND THEIR RELATIVES

In the basin of a fountain, or in a wooden watering trough for horses, you will see, if you look carefully, slender, green, thread-like things that float on the surface of the water, or lie close to the wall of the basin. If you are in the country where there

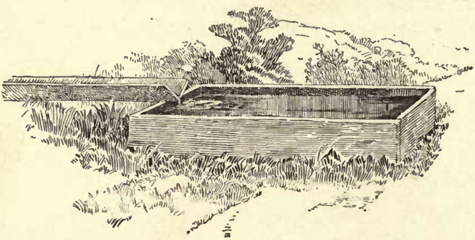


FIG. 53. WOODEN WATERING TROUGH

are ditches, and ponds, and lakes, and running streams, you will see the same kind of green, thread-like plants clinging to rocks or lying on the surface of the water.

Many grown-up people who see these plants on the surface of ponds look upon them with disdain because they bear no flowers and are not good to eat. They even call them *pond-scum*. But that

is because they have never taken the trouble to look at them with a magnifying glass. If they had,

FIG. 54. A POND IN WHICH THREAD-PLANTS GROW

they would have discovered that even little things may teach useful lessons, and may be quite as wonderful in their way as things more easily seen.

Let us take out from the water a handful of these plants and put them into a tumbler. Moving them does not seem to break or to injure them in the least, although they are so long and so very slender. Now with a needle we will place one or two of these plants on a glass plate and look at them with a strong magnifying glass. Under the magnifying glass they do not look so slender, and each plant seems to be divided into small chambers which lie very close together.

FIG. 55. THREAD-PLANTS IN A TUMBLER AND ON A GLASS PLATE

These chambers are called cells because they are so small and yet are enclosed by walls like the rooms of a prison. Just

as the prison cell is made to contain a living being, called a prisoner, so the cells of this plant are made to hold a living substance called *protoplasm*. There are two kinds of protoplasm in each cell; a small, dark, more solid kind, called a nucleus, and a lighter-colored, jelly-like kind that surrounds the nucleus. The cell cannot live unless it contains both kinds of protoplasm.

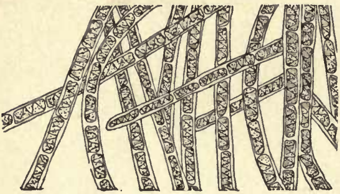


FIG. 56. THREAD-PLANTS MAGNIFIED

The living substance appears green in this plant because there are small particles of green coloring matter scattered all through it. If these green particles are removed, the living substance is seen to be colorless and so clear that one can almost see through it. You can prove this for yourself by pouring some alcohol over a few of these plants. Alcohol washes out the green particles so that the plants become white. This is a sad thing for the plants, however, for it costs them their lives. If the alcohol is strong, it kills the living substance in

FIG. 57. A THREAD-PLANT GREATLY MAGNIFIED TO SHOW THE PARTS OF A CELL

the cells, and when this is dead, the plant is dead, since all its parts are made from protoplasm.

But you are wondering why these green particles are in the living substance at all. They are there because this tiny plant is a living thing like yourself, and just as you must eat to live, so this plant must have food. Your food consists of the bread, and meat, and vegetables, and fruit which your parents provide for you.

But this plant, although so much smaller than you are, makes its own food by means of this green coloring matter. The green coloring matter is the plant's cook, so to speak. The stuff from which it prepares food it gets from the air and from the water with which it is surrounded. When your mother cooks food for you, she uses a stove, or heat of some sort, does she not?

The cook of this tiny plant has a wonderful stove; for though the plant is so small, its stove is bigger than this earth — thousands of times bigger — and it is so far away that if the plant's cook were to be sent to its stove, it would take hundreds of years for it to get there, even if it were to go in a flying-machine. You now know without being told that this plant's stove is the sun, and that it is the sun's rays which enable the green coloring matter in the plant to prepare food from the materials in the water and air. And so the plant grows and grows. Ah, that is the very thing you wished to know!

"How does the plant grow?" Well, when the food is being made, little particles of the air and of the surrounding water are taken into the substance of each cell, and the more that is taken in, the bigger each cell grows, just as your purse swells and gets bigger when you put money into it. If you had a purse so full of money that it could not hold any more, would it not surprise you if it should divide into two equal and complete purses in your hand so that not a bit of your money would be lost, but you would have two purses instead of one, and each

FIG. 58. THE DIVISION OF A CELL IN A THREAD-PLANT

just as full of money as the other? No one has ever seen or heard of such a thing happening to a purse; yet that is precisely what happens to this plant-cell. When it is full-grown, from the living substance in the mother-cell a wall is built through its middle which separates the contents into two parts. Each of these parts continues to make its own food and to grow until it becomes as large as the cell from which it was formed.

When the newly formed cells have become full-grown, each divides again, making four cells; then these four divide again until at last a long ribbon-like plant is formed like that you see in Fig. 58.

But where did the first cell, which we call the

mother-cell, come from? The mother-cell was once a baby plant, of course, and now I will tell you how it grew.

As you see from looking at these plants in the glass, the threads or tiny ribbons lie quite close together. In Fig. 59 two of these plants have been selected for observation and drawings made of them as they look under a magnifying glass. In some places you see that little bridges of living substance have been formed between two plants. These bridges extend from one cell to the other. When a bridge has been securely formed, the protoplasm of one cell passes over into the other cell and uniting with it forms a roundish body, surrounded by a heavy wall. This roundish body is called a spore, and a spore is able to live for a long time without food or water. This spore is a real plant-baby.

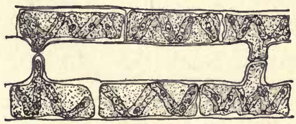


FIG. 59. THE FORMATION OF BRIDGES OF LIVING SUBSTANCE IN TWO ADJOINING THREAD-PLANTS

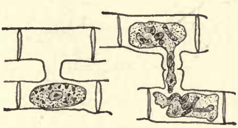


FIG. 60. THE LIVING SUBSTANCE IN THE CELL OF A THREAD-PLANT PASSING OVER AND UNITING WITH THE LIVING SUBSTANCE OF A CELL IN ANOTHER THREAD-PLANT

After a time it breaks away from the other cells in the plant body, and if it happens to be surrounded by water and in the sunlight, a slender projection of the protoplasm is put forth at one side. After a time this pro-

toplasm divides into two parts, and so a new plant is formed just like the ones from which the plant baby came.

Now that you have learned something about this plant and the way its children grow, you will

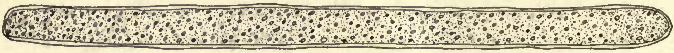


FIG. 61. A THREAD-PLANT THAT CAN LIVE ON THE EARTH AS WELL AS IN WATER

perhaps wish to know its name. It is called *Spi-ro-gy'ra*, because a part of the contents of the cell lies in a spiral ribbon within the walls.

Not all children of thread-plants grow like those of Spirogyra. Another plant which looks something like Spirogyra, but which can live on the earth as well as in water, has two different ways of caring for its children.

You readily see from the picture that it, too, is ribbon-shaped; but there are no cross-walls dividing the ribbon into cells as in Spirogyra, except at the ends of some plants. As you see in the picture, the ends become rounded, and a wall shuts off living substance in this end from that in the rest of the plant. Little hair-like projections form all over the surface of this rounded portion of the plant, and then the wall opens and lets the entire contents swim away in the water. This

FIG. 62. A WALL FORMED ACROSS THE END OF THE PLANT IN PREPARATION FOR THE GROWTH OF A NEW PLANT

is the new plant baby; and it is as small as the tiniest speck of dust, but just as much alive as your kitten.

After a time this tiny plant baby comes to rest and the living substance of which it is made grows out at the sides in the way you see in Fig. 63. If it happens to be in water when it begins to grow, it simply lies still and keeps on making its own food and growing until it is time for another baby plant to form. If it happens to be on top of the earth, a sort of structure like a hand, or like the roots of a tree, grows out at one end to hold it fast. This structure is therefore called a hold-fast.

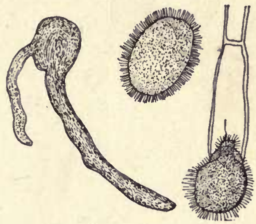


FIG. 63. THE BABY PLANT ESCAPING AND ITS GROWTH INTO A NEW THREAD-PLANT BEGUN

But plant babies grow in still another way in this plant. At certain times, a bud-like projection forms on one side. Soon another projection forms near it, as shown in the picture. Both buds are separated from the mother-plant by a wall. As the buds grow they take on different shapes, however. One becomes large and oval, and is known as the mother-cell. The outer bud becomes long and slender, and is known as the father-cell. The living substance in the mother-cell rounds up into

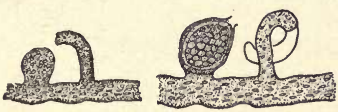


FIG. 64. STRUCTURES FORMED BY BUDDING IN WHICH EGGS AND SPERMS GROW

one large mass, called the egg, and an opening forms in the wall at one side. The living substance in the father-cell divides up into a large number of small parts, each with two hair-like projections.

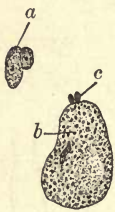


Fig. 65. The Union of an Egg Cell and a Sperm Cell
a. Sperm cell.
b. Egg cell.
c. Egg and sperm nucleus uniting.

Each of these living parts is called a sperm cell. Several sperm cells enter the oval cell through the opening at the side, but only one unites with the egg. A heavy wall then forms around the egg, and this soon breaks off from the old plant and lives a long time without food. Then the heavy wall bursts, the living substance inside of it divides into two parts, then into four, and so continues to divide until a new plant is formed. But no walls are formed around the new cells which make the body of the plant. Only the parts that are to help make a baby plant have walls in this plant, which we call *Vau-che′ri-a*.

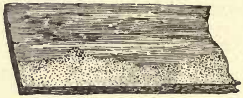


Fig. 67. Single Celled Plants growing on an Old Board

Fig. 66. The Early Growth of the Plant Baby

There are green plants living about us which are even simpler than Spirogyra and Vaucheria. If you look on some tree trunks, old fences, or boards that have been wet frequently by dripping water or rain, you will see what appears to be a green mould or stain. If you scrape off some of this

and place it under a magnifying glass, you will see little, round, green cells. Each cell is a plant. It never gets any bigger.

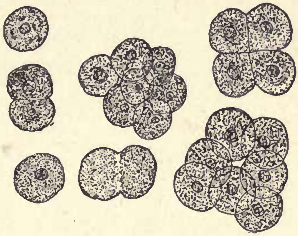


FIG. 68. SINGLE CELLED PLANTS MAGNIFIED

You may see several of these plants clinging together. Fig. 69 is a picture of one of these cells which has just divided its body into two cells. These two cells may separate or they may cling together, and each divides until groups like those shown in the picture have been formed. But each plant in the group can live just as well by itself as in company with others; and the only way that its children can grow is from the division of the cell-body of the mother-plant, because there is no father-plant, as in Vaucheria. Each cell that divides may be said to be a mother-plant. This pretty little round plant is called *Pleu-ro-coc′cus.*

FIG. 69. A SINGLE CELLED PLANT GREATLY MAGNIFIED IS SHOWN DIVIDING INTO TWO

CHAPTER III

BACTERIA, THE SMALLEST PLANTS OF ALL

SIMPLE as the Pleurococcus seems, and small and low in its form, there are many plants still smaller. These plants live floating about in the air. They also live in water, in the earth, in all kinds of decaying substances, like rotten apples, or in ill-smelling meat. But some of them are found in living things, too — even in boys and girls and grown-up people.

They can live in the dark as well as in the light, for they never make their own food. This is because there is no green coloring matter in the protoplasm of which they are made. No one knows why they have no green coloring matter. Some think they lost it by trying to get food without making it themselves. Some think they never had any green in their bodies. However that may be, they get on very well without it, and there are so many of them in the world that even in a space as big as your garden there are more of these plants living than you could count in all your life, even if you counted all the time and never stopped to eat or sleep. They are so small that you could hold many hundreds of them on the point of a needle.

There are many kinds of bacteria. Some are round, some are shaped like a pencil, and others are shaped like a cork-screw. Some are smooth, and others have long hair-like structures all over the surface. But they are all small, and they are all called bacteria. Of course, each different kind has a name to distinguish it from other kinds; but we need not trouble ourselves about such names. It is enough to know that these very tiny, colorless plants are called bacteria.

When fields are plowed, or wheat is made into flour, or iron and coal are dug from a mine, we say that useful work is being done. When houses are burned, or machines broken, or grain destroyed by a storm, we say that harmful things are done. Some bacteria, though so very tiny, can do more good work than many plowmen, or millers, or miners. But some bacteria do more harm than a big fire or even a terrible storm can do.

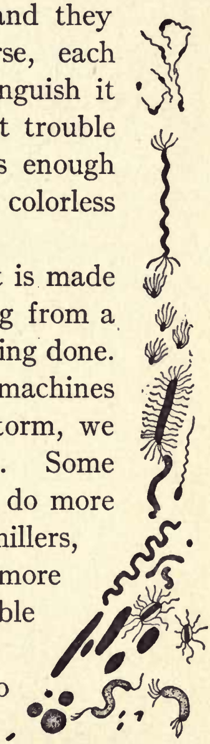


FIG. 70. VARIOUS KINDS OF BACTERIA

Perhaps you think this strange, so I will tell you about some of the good things and about some of the harmful things done by bacteria. Of course they do not mean to do either good or harmful things. As long as they are alive they must have food. In getting food they must do a certain amount of work. Sometimes this work

happens to be a good thing for human beings; sometimes it is bad.

We all enjoy having pretty linen tablecloths and napkins, and linen dresses, and linen collars that shine when they are ironed. What do you think linen is made from? It has to be woven, of course, in a loom; but the threads of which it is made are the fine fibres of the stem of a plant called flax. There are many coarse fibres in a flax stem that cannot be used for cloth, so these must be separated from the fine, soft ones, and thrown away. All the fibres are held together by a sort of gum, and it is very hard to remove this gum and separate the fibres. When the flax is put into a tank full of water a great many bacteria settle in the water to get food. They eat away the gummy substance and so the fibres easily fall apart. If the bacteria did not do this work of separating the fibres, we should not have any linen, for we do not know how to do without the help of bacteria. In the same way, bacteria help us to prepare door mats, brushes, sponges, and leather.

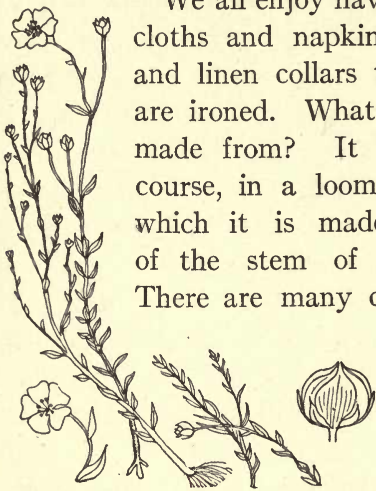


FIG. 71. A FLAX PLANT

FIG. 72. BACTERIA USEFUL IN DAIRYING
a. Bacteria used for ripening cream.
b. Bacteria which give a pleasant taste to butter.

Not only does their work help us in preparing clothing, but the pleasant taste of some foods is due to their activity. This is especially true of butter and cheese. Where large quantities of butter and cheese are made, a great many bacteria of a special kind are also kept to put into them in order that the taste or flavor may be improved.

Perhaps you know that a man who removes waste matter from our houses or lawns is called a scavenger. But men-scavengers are found only in cities and towns, and they carry away only such things as can be contained in a big tin can, or loaded on a wagon. There are many other kinds of waste in the world that are not and cannot be taken away in wagons by men-scavengers.

When big trees in the forests fall; when every year all the leaves fall from the trees and all the soft-stemmed plants die, this makes so much waste that not all the scavengers of a big city could carry it away. Also, every year many animals die — horses and cows and sheep and goats and tigers and elephants and birds and grasshoppers — and of course it would be impossible for men-scavengers to carry away all these dead animals. Besides, where could a place be found for them? If neither plants nor animals decayed, the earth would soon become covered up with them so that there would not be room for men to walk or for plants to grow. But there are bacteria which can eat and grow in such waste matter as dead animals, and

plants, and fallen leaves, and as they eat and grow they change these substances that are taken up by the earth and the air, so that there is no need of men-scavengers to carry things away. This change brought about by bacteria is called decay or decomposition.

The change that the bacteria bring about by their work is so slow that it does not harm the air or the earth. Indeed, it does the earth much good, for, as you know, the earth is very old, thousands and thousands of years old, and since it has given food to so many plants, it might get tired and worn out. But the work done by the bacteria in changing dead animals and plants into the same things that the earth has already given to plants keeps it always young and strong and fresh. That is the reason plants can grow up out of the earth year after year and always get food enough.

FIG. 73. BACTERIA WHICH TAKE NITROGEN FROM THE AIR AND PUT IT INTO THE SOIL

Bacteria not only help to give back to the earth the materials that the earth has given to the plants, but they also take a substance called nitrogen from the air and put that into the earth so that green plants can get it for food. Green plants cannot live without nitrogen, but they are not able to take it from the air themselves. So, you see, the bacteria are their good friends and helpers.

Some plants, such as beans, peas, and clover, need much nitrogen; large numbers of bacteria

live in their roots and make a substance for these plants which contains the nitrogen they need. Is it not wonderful that such little plants as the bacteria can do so much good work? It is not only because they are small that they can do so much, but because there are so many of them. And now, before I tell you about the bacteria that do harm, I want to tell you how the children of the bacteria grow.

FIG. 74. BACTERIA WHICH MAKE FOOD FOR PEAS

A bacterium becomes grown-up in about a half-hour. If it then is warm enough and has plenty of food, its body divides into two parts in the same way that we have already seen the Pleurococcus do. These two parts may be said to be the children of the bacterium that divided. These children look just like their mother, and in half an hour each of them is grown-up. Then each of these divides into two parts, and in a half-hour their children divide again.

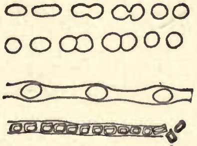


FIG. 75. BACTERIA DIVIDING

Do you know how long it takes to count to 1,000? Then to 2,000? If I should tell you that one of those little plants in Fig. 75 divides so often that in twenty-four hours there will be more children than you or I can count in one year — would it not surprise you? In two days there would be many more bacteria than there are people in the whole world. In three

days there would be so many that we would not be able to weigh them together in the biggest scale that ever was made, for they would weigh more than the capitol building at Washington. It is because there are so many of them that they can do so much work even if they are small. There would be many more bacteria in the world if all that are born could find food enough. But many die of hunger, and others die from a poison that is made when the bacteria feed, and is then passed out of their bodies into the food they live upon.

As I have said before, they can do great harm as well as good. They get into sweet milk and turn it sour. If a certain kind of bacteria gets into milk, the milk tastes bitter. Still another kind makes it taste like soap; another kind makes it slimy. It is very difficult to keep the bacteria that turn milk sour out of it, because they may live in the cow's milk bag or udder, and so are already in the milk when it is drawn into the milk-pail.

FIG. 76. BACTERIA WHICH TURN MILK SOUR

But other bacteria can usually be kept out of milk if care is taken and cleanliness is observed. Cows should be kept clean and in clean barns, and milked by men whose hands and clothing are clean, for of course bacteria live on our hands, especially on dirty hands; and they live in clothing, especially in dirty clothing. They also live on hay that is fed to cows, and in corn fodder, so the milkman

should be careful about the food that is fed the cows. Then we should be very careful not to take milk from a sick cow. Do you know that cows become sick just like people? And some of the

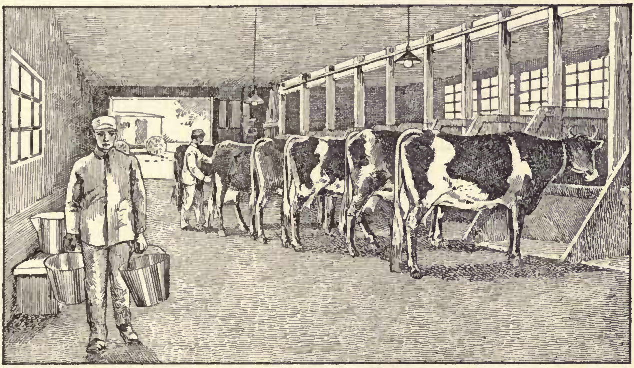


Fig. 77. A Barn in which the Cows and the Milk are kept Clean

diseases of a cow may be given by the cow through her milk to little children and to grown people too.

One of the most terrible of these diseases is consumption, a disease of the lungs which causes the death of thousands of people every year. This disease is caused by a slender, rod-shaped bacterium. It usually grows slowly, but is hard to kill. It has not been proved in many cases that the bacteria of consumption in cow's milk make people sick; but if a cow has this disease, this bacterium gets

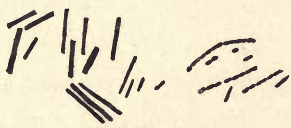


Fig. 78. Bacteria which cause Consumption

into the milk bag, and from the milk bag into the milk-pail and so into homes where the milk is used for people to drink. Once in the stomach or intestines of a person, they are taken by the blood to the lungs, and here the bacteria find much food and a good place to live. But you have already learned how fast the bacteria increase in numbers and how much work they can do. So in two or three years, sometimes in a few months, they have poisoned and injured the lungs of the person they live in so that the person cannot live.


FIG. 79. A TOMATO-PLANT WILTED BY BACTERIA

Instead of taking up their home in the lungs they may get into the bones, when the person whom they infest becomes lame or crippled so that he can neither work nor play. Very often boys and girls become crippled in this way, and they may remain cripples all their lives. Sometimes the bacteria are taken by the blood to the skin, the kidneys, or some other organ or part of the body, and here they always do harm, and usually cause death. So every one should be careful not to use milk from a sick cow.

But the bacteria that cause consumption may get into the body in other ways than in milk. They may get into the air through the sputum of a person sick with consumption, and then be drawn into the

body of boys and girls by the breath. They may be carried about by flies, and so placed on our food when the fly alights on it. The dishes used by a consumptive may contain the germs, unless care has been taken to kill the germs before the dishes are again used. Every boy and girl ought to know that it is dangerous to drink out of a public drinking-cup, or to use a towel or wash-bowl in a railway station or other public place where sick persons may have used these articles previously.

Bacteria which cause disease are often called germs. Germs cause many other diseases in human beings, some of them even more terrible than consumption in the pain and misery to which they give rise. Since some of these diseases make so many children sick, we will explain how care can be taken to prevent bacteria from harming children through these diseases when we have learned more about how children grow and what they need to make them happy and healthful.

Bacteria also cause disease among pigs and chickens, cows and horses, and all other animals. They also attack plants and cause disease in pumpkins, melons, cucumbers, tomatoes, corn, and even in flowers and trees.

CHAPTER IV

PLANTS THAT POSSESS NO GREEN COLORING MATTER

There is another very common kind of plant which contains no green coloring matter and whose children grow in two different ways. This plant you have seen often, although perhaps you did not know it was a plant at all. Jelly and jam, preserves and cake, are considered good food by boys

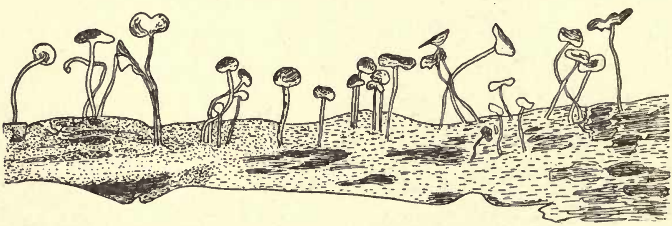


Fig. 80. Plants which possess no Green Coloring Matter growing from an Old Log

and girls. No wonder then that a little colorless plant that cannot make any food for itself should like these things. So, often when the covers are removed from jelly-jars or fruit preserves, a white fuzzy growth may be seen on them.

You can watch it grow if you moisten a piece of bread and place this in a warm room under a

tumbler. Within a short time, masses of slender white threads will be seen, looking almost like the threads in white velvet cloth.

FIG. 81. COLORLESS PLANTS GROWING ON THE STEM OF A TREE

But when one looks at these threads through a magnifying glass they appear like the picture in Fig. 83. From this you will see that the upright threads bear black, round, knob-like structures; some threads run lengthwise; others project downward like roots or hold-fasts. The hold-fasts and the threads running lengthwise collect and carry nourishment taken from the preserves and bread. The upright threads receive the nourishment in order that plant children may form from the living substance within them. Very soon the living substance at the end of each upright thread becomes separated from the rest of the thread, rounds up into a tiny ball with a black covering, and falls off from the mother-thread.

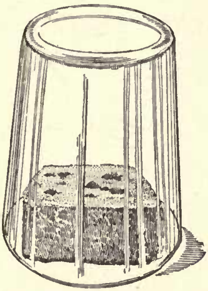


FIG. 82. MOLD GROWING ON MOISTENED BREAD

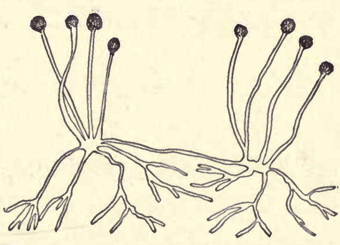


FIG. 83. APPEARANCE OF MOLD PLANTS WHEN SEEN UNDER A MAGNIFYING GLASS

The covering soon bursts and thousands of tiny little rounded particles fall out. Each of the tiny particles consists of living substance like that in the mother-thread from which it was made, and is called a spore. This spore is too small to be seen by the naked eye, and if it falls in a dry place is usually taken up by the air and blown about from place to place. In this way it gets into bread and cake-boxes, and even into jellies and preserves, if these are not covered very well indeed.

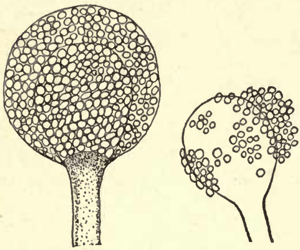


FIG. 84. THE SPORE CASE OF A MOLD BEFORE AND AFTER THE WALL HAS BURST

Once inside and settled in moist, rich food the living substance in the little spore begins to grow, and soon a new plant is formed which produces a new lot of spores. These spores are scattered on the surface of the food-substance and soon thousands of little white plants are growing where was only one before.

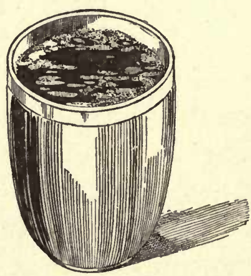


FIG. 85. MOLD GROWING ON JELLY

Although so many plant children grow from one little plant in this simple way, young plants may form by the union of the living substance of two plant-threads. Instead of forming round spore sacs, two threads may grow toward each

other and enlarge. A wall forms between the end substance and the rest of the threads. Then the substance in the two cells thus formed unites into one cell, and so one new mother-cell is formed from the living substance of two different plants. This mother-cell begins to grow as soon as it falls upon some moist food-substance, and then a new plant is formed. It may be carried about by the wind, however, from Minnesota to New York, or from Wisconsin to Kentucky, or even farther, because its covering is strong and it can live a long time without food.

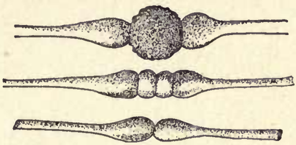


FIG. 86. THE UNION OF THE ENDS OF TWO MOLD PLANTS TO FORM A BABY PLANT

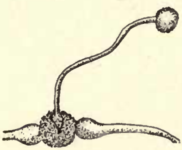


FIG. 87. THE WAY A BABY MOLD PLANT GROWS

All plants that are white and whose children grow in the ways described above are called molds. There are many different kinds of molds, and they live in all parts of the earth that are not encrusted with salt, or that are not covered with ice. They thrive especially well in warm places in foods made of sugar or starch.

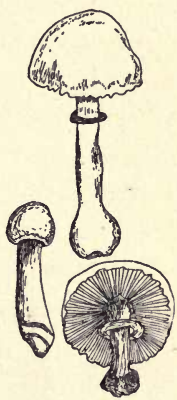


FIG. 88. MUSHROOMS

There are still other plants with no green coloring matter which you have seen growing from the

moist earth, on lawns, or in the deep woods, or even by the roadside. Occasionally they may be seen growing on the trunks of trees or from rotting logs or boards. Some are called mushrooms, and others are called puffballs, or toadstools, and many of them are good to eat.

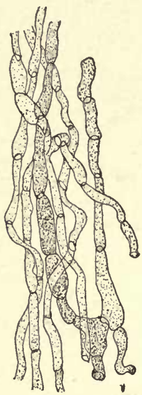


FIG. 89. COLORLESS THREADS WHICH FORM THE BODY OF THE MUSHROOM OR TOADSTOOL

All of these plants are quite large, some of them being more than one foot in width and almost as high. But really they are all big cities of white threads like those of the mold, only the threads lie close together on a stalk, and then spread out above into a round or umbrella-like structure. Spore mother-cells are formed in the top or umbrella-like structure and the nourishment passes up to them through the threads that form the stalk. Each spore may be said to be a plant baby, and in the mushroom and toadstool they are attached to the mother-thread in the way shown.

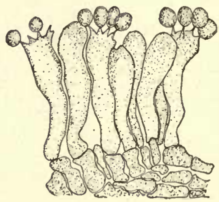


FIG. 90. THE SPORES, OR MUSHROOM PLANT BABIES, AT THE TOP OF THE THREADS, INSIDE THE SPORE CASES

FIG. 91. AN EARTH-STAR PUFFBALL

In puffballs, the entire ball is filled with spores,

and when the covering of the ball bursts, the spores are carried all about by the wind.

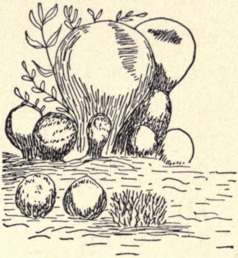


FIG. 92. A COMMON PUFFBALL

We have learned that the children of plants without any green coloring matter may grow from spores, or from a mother-cell formed from a part of the living substance of the two plant-threads. Some are formed directly by the division of the plant-mother's body into two parts.

CHAPTER V

LOW, GREEN, LEAF-LIKE PLANTS

DID you ever see a plant growing that looked like those in the picture below? Most people who see such plants in moist, shady places think them mosses because they are so low and grow so close to the ground. But they are not mosses at all. They

FIG. 93. LOW, GREEN, LEAF-LIKE PLANTS GROWING BY THE BROOKSIDE

were called *Liverworts* long ago by people who used them as a remedy in diseases of the liver, and we still call them by the same name.

The plant in the picture is one of the liverworts that grows in many places of the earth, usually near streams or lakes, and is therefore often seen. It has a pretty name, not more difficult to pronounce than Marguerite. It is *Mar-chan'ti-a*.

As you see, the body of Marchantia is flat, like an oak-leaf, and it is broader than a grass blade. It may become four or five inches long and more than an inch wide. It forks as it grows, so that it looks notched. The upper surface of the plant-body is marked off into little diamond-shaped spaces and each space has a hole or opening in its middle. What do you think this opening is for? It is one of the many mouths possessed by the plant, and is used in the same way that our mouths are used — to take food and air into the body. For the body of Marchantia has thickness as well as length and width, and there are several cell-layers lying close together. In order that the innermost cells may get air, a passage from the outside is formed, and the hole or mouth is the opening to such a passage.

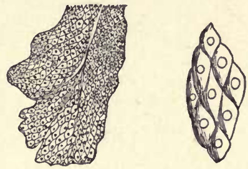


FIG. 94. A PART OF A MARCHANTIA SHOWING THE OPENINGS FOR AIR TO PASS THROUGH

FIG. 95. THE LITTLE CUPS ON THE BODY OF MARCHANTIA WHICH CONTAIN THE BUDS OR NEW PLANT BABIES

Can you tell why Spirogyra, Vaucheria, and Pleurococcus have no such air-passages and mouths? And why are there no mouths in any of the plants that are without green coloring matter?

There are many plants whose children are never

formed from the division of the mother-plant's whole body, as in Pleurococcus and in the bacteria, but grow from a special part of her body, set aside and nourished for that purpose. In Marchantia the plant children are formed in two ways. Little cups grow out from the upper surface of the plant, and inside the cup many little green baby plants grow. They are kept inside the cup until they are big enough to make their own food. Then they fall out of the cup on the ground and grow up into big plants. In this way many plant children can grow in a short time.


FIG. 96. A MARCHANTIA FATHER-PLANT

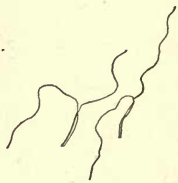


FIG. 97. THE SPERM CELLS FROM THE SACS IN THE FATHER-PLANT

But the children of Marchantia form in still another way. Certain plants become father-plants and others become mother-plants. Stalked structures grow out from the father-plant that look like Japanese umbrellas with short handles. You may see how they appear in Fig. 96. Little sacs are formed in the upper part of the umbrella-like structures, and here a great many small cells or sperms are formed. Each sperm is very small, long, and narrow, and has two hair-like projections at one end.


FIG. 98. THE MOTHER-PLANT IN MARCHANTIA

In the mother-plant a structure grows out that looks like a star at the end of a long, slender rod. Bottle-shaped structures grow from the under side of the star-shaped structure, and in each bottle is an egg. After a rain or a heavy dew, when grown-up plants are covered with water, the sperms leave the sacs of the father-plant and swim toward the flasks of the mother-plant. One of the sperms enters the mouth of a flask and swims down the neck until it reaches the egg. Then it unites with this, and at once a baby plant is formed, which never leaves the mother-plant, but remains there until it is fully grown.

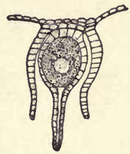


FIG. 99. THE EGG IN ITS BOTTLE-SHAPED SAC IN THE MOTHER-PLANT

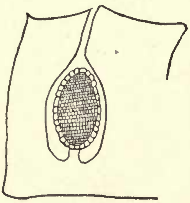


FIG. 100. THE NEW PLANT BABY

This baby plant does not look like its mother or father either, for it has a stalk, or foot, and a cup-shaped top. Through the stalk, or foot, it gets food from the mother-plant, and it never leaves to make its own food. But the mother-plant cheerfully feeds it, because in its cup-shaped part numerous cells develop which are protected by heavy walls, and so are able to live through the coldest winter. Each of these cells is really a plant baby. It falls

FIG. 101. THE PLANT BABY GROWN AND READY TO SEND HUNDREDS OF OTHER PLANT BABIES OUT INTO THE WORLD

on the earth, and when warm weather comes it grows into a plant just like its grandmother, the green Marchantia. If the Marchantia did not have grandchildren able to live through the winter there would not be so many Marchantias in the world as there are now to be found.

Fig. 102. Growth of a Grandchild of Marchantia

CHAPTER VI

MOSS PLANTS AND THEIR CHILDREN

Every one knows and loves a moss, for mosses grow almost everywhere. In the moist, warm climate of the south there are many kinds of moss, and some kinds grow quite tall. In the north, where winter lasts almost all the year, and where no trees can grow or flowers bloom, there the brown little mosses grow under the snow. Near the tops of high mountains and down in the pleasant valleys — everywhere, mosses find homes for themselves and for their children. And there are so many moss children every year! Some of them grow right out from their mother's side, without waiting for eggs and sperms to be formed at all. That is the reason moss plants stand so close together that they are almost like the pile of a velvet carpet.

Fig. 103. Moss Plants

At certain times of the year, however, moss children grow in another way. If you look at a

group of moss plants in July, August, or September, you will find a rosette of leaves at the end of the main stem or at the end of a branch. This rosette is sometimes called the moss flower; and as we shall see when we talk about the flowering plants, this is really a good name for it, although it looks so different from a real rose.

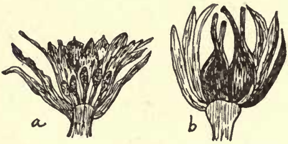


FIG. 104. MOSS FLOWERS
a. Club-shaped structures where the father-cells grow.
b. Flask-shaped structures where the mother-cells grow.

When we look carefully at this rosette, we find in its centre some club-shaped and some flask-shaped structures. Each flask-shaped structure contains an egg, and each club-shaped structure contains very many sperms with long tails. The tails are to help the sperms swim. Of course, the sperms cannot swim unless there is water to swim in; but they are so small that they do not need very much water, — the dew that is left on the mosses at night or an occasional rain furnishes them with all they need for moving from the club-shaped structures where they grew to the mouth of the flask-shaped structures.

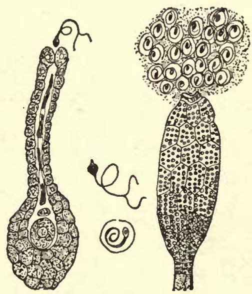


FIG. 105. THE FATHER-CELLS MAKING THEIR WAY TO THE MOTHER-CELL

One of the sperms enters and passes down the neck of the flask, until it reaches the egg. Then it

unites with this, and the egg-substance to which the sperm-substance has been added immediately begins to divide, and from it a baby plant grows, which in time looks like the picture in Fig. 106. This is a real plant — a child of the plant with the leaf-like parts and the flower rosette; only, instead of growing out of the ground, as its parent did, this baby plant grows out of its mother's body and never leaves this. It becomes a real, grown-up plant and has children of its own, hundreds and hundreds of them, all crowded close together in the little urn-shaped house you see at the top of the stalk.

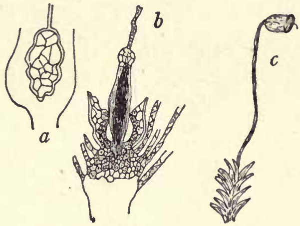


FIG. 106. THE GROWTH OF THE NEW PLANT BABY

a. Beginning of growth.
b. Young plant.
c. Full-grown plant.

FIG. 107. THE HOME OF THE SPORE CHILDREN AND THE WAY THE DOOR OPENS TO LET THEM GET AWAY

Of course, each one of its babies is very, very small, and it will amuse you to learn how these moss babies get out. Instead of having doors in their house as people do, there is a circular lid at the top. When the moss babies are ready to leave their house, this lid opens and they are lifted out by the teeth about the rim. These teeth can bend inward and outward in the way you bend your

hand at the wrist, and as they bend they throw some of the plant babies out upon the ground.

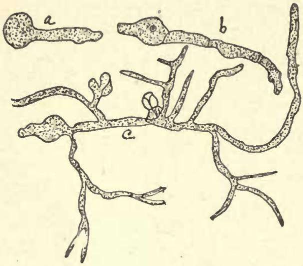


FIG. 108. THE GROWTH OF A SPORE BABY INTO A MOSS PLANT LIKE ITS GRAND-MOTHER

This seems a cruel thing to do; but these plant babies are not hurt in the least, for they are *spores* and are tucked up safe in a hard brown covering. If they fall upon moist ground, they begin to grow at once, and when they are grown-up they look just like their grandparents — and not like their mother at all. Of course, some boys and girls look like their grandfathers and grandmothers, but all moss children *must* look like their grandparents, unless they grow out from the sides of the parent's body.

Do you not think moss children grow in a curious way?

CHAPTER VII

THE CURIOUS GROWTH OF A FERN

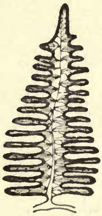
ALMOST every one knows something about some kind of grown-up ferns; but how many know what fern children look like or how they grow? You think the furry, downy, green little roll that comes

FIG. 109. THE WAY A FERN-LEAF UNFOLDS

out of the ground in the early springtime is a fern baby. But it is not a fern baby at all. It is only the leaf of a grown-up fern plant. The baby fern doesn't look any more like the grown-up fern than a fish looks like a bird.

If you look on the under side of the leaf of a bracken you will find all around the edge of each

leaflet a narrow brown band. In the maidenhair fern the under side of the leaf looks as if it were decorated with the most delicate embroidery. The narrow brown band and the delicate embroidery are the homes of countless fern babies. Learned people call them spores, and they really are very much like the spores we found in the mosses. You can see for yourself what the spores look like if you shake a fern-leaf over a white paper. The paper will become covered with little brown, dust-like particles. Other ferns have differently shaped and differently placed houses for the spores — but the spores look very much the same in all ferns.



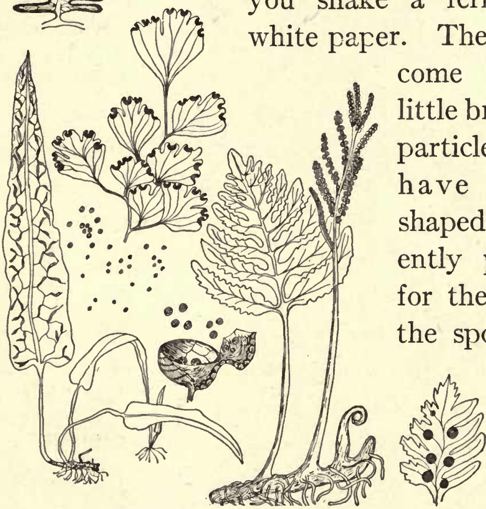


FIG. 110. THE HOMES OF SPORE CHILDREN OF DIFFERENT KINDS OF FERNS

Place some of these brown particles or spores of the bracken on some moist earth, and the living substance in each will at once begin to grow and a little green plant will soon be seen. It does not look like a fern, however, for when it is full-grown it is smaller than

your finger-nail and shaped something like your heart, although it is as thin and flat as a leaf. A great many little white threads grow from the under surface and hold it to the ground. This is the plant which becomes the real mother of the bracken which we see in the woods or by the roadside, for certain cells in this little plant's body divide and form flask or bottle-shaped structures, each of which contains an egg. Certain other cells form sacs which are full of sperms.

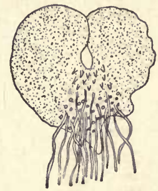


FIG. 111. THE HEART-SHAPED MOTHER-FERN

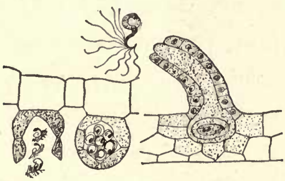


FIG. 112. THE SPERM FATHER-CELLS MAKING THEIR WAY TO THE MOTHER-CELL IN THE FLASK-SHAPED STRUCTURE

As you see in Fig. 112, the egg looks very much like the egg of Marchantia or the egg of the moss. But the sperms are very different. Each has a spirally coiled body with a great many tails. When the eggs and the sperms are full-grown, the sperms reach the eggs by swimming in the water, and one sperm unites with each egg. The united egg and sperm then divides into cells, all of which cling together and at last grow into a new plant, a real fern baby. But strange to say, only a part of this fern baby ever

FIG. 113. THE NEW BABY FERN GROWING OUT OF ITS MOTHER'S BODY

gets to live above the ground. Its roots and stem remain always under the ground, and only the leaves break through the earth and lift themselves into the sunlight. That is the reason you see them slowly unrolling themselves early in the spring.

FIG. 114. YOUNG FERN-LEAVES

For a short time the new fern gets nourishment from the body of the little heart-shaped mother-plant; but soon its own roots strike into the soil, and when its leaves have made their way into the air and sunlight, they are able to make all the food the growing plant needs.

CHAPTER VIII

THE CHILDREN OF THE PINE FAMILY

Do you know what a pine baby looks like? Many plant children resemble the children of the pine, for it has many relatives. It is not difficult to see that a hemlock, a cedar, a spruce, and a tamarack look more like a pine than an oak. That

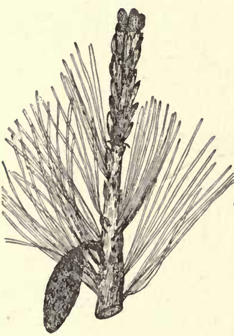


FIG. 115. A BRANCH OF A PINE TREE

FIG. 116. A BRANCH OF A LARCH

FIG. 117. A BRANCH OF HEMLOCK

is because they all belong to the pine family of trees. We know that cousins and second-cousins among boys and girls often look somewhat alike, and cousins and second-cousins among trees do the same.

The members of the pine family of trees have a

stem, which when full-grown is so big that we call it a trunk. This stem or trunk is woody and very strong and carries huge branches on which the leaves are borne. The leaves are either needle-shaped, with several in one sheath, or they are short, flat, green scales. The roots, too, are big and stout, and grow deep into the ground.

FIG. 118. A BRANCH OF WHITE CEDAR

FIG. 119. A BRANCH OF SPRUCE

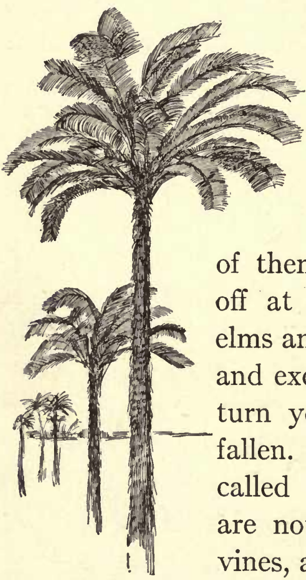


FIG. 120. FERN-LIKE EVERGREENS

The members of the pine family of trees do not resemble one another very closely in habits. In some of them all the leaves do not fall off at one time, as the leaves of elms and maples do in the autumn, and except in the larch they do not turn yellow until after they have fallen. Therefore they are often called Evergreen. Some of them are not trees at all, but climbing vines, and others never become bigger than hazel-bushes. In very warm countries there are forms of this family which look like ferns.

And where do you think the pine children grow? Out of the ground? Yes, but not until they have become big enough to take care of themselves. While they are little and unable to care for themselves, a special place is made for them to grow in. This place we call a cone. Two different kinds of cones must be made before a pine baby can grow. One of these is quite large, larger than your hand. It grows at the tip-end of a branch, or between two branches. It is made of broad, scale-like leaves, which become quite thick and hard and packed close together.

FIG. 121. A PINE-CONE TWO YEARS OLD WITH THE UPPER HALF CUT AWAY

On the upper part of each scale leaf are two small bags, and in each bag is a large, oval spore. The scale leaf bearing this spore is called a carpel. All the scale leaves on the cone are carpels, and the entire cone is therefore called a *carpellate* cone. The tree which bears the carpellate cones is called the female or mother-tree, because the pine babies are all fed from her body.

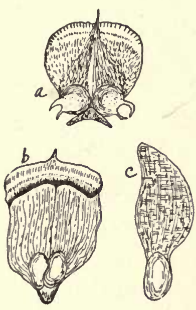


FIG. 122. THE SCALES OF A CARPELLATE CONE BEARING THE SEEDS

But no pine babies could ever grow if there were only mother pine trees in the world. There must also be father pine trees. The father-pines look just like the mother-pines, but the cones they

bear are different. They are smaller and the sacs on their scale leaves are on the under surface, not on the upper as in the carpellate cone. Each sac on the scale of the cone of a father-pine contains a great many small spores. These spores are usually called pollen or pollen-grains. The sacs are called pollen sacs. The thick scale leaves which bear the pollen sacs are called *stamens*, and the whole cone is called the *staminate* cone. The tree which bears the staminate cones is the male or father-tree.

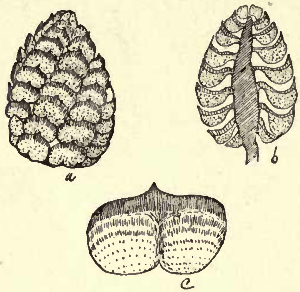


FIG. 123. THE STAMINATE CONE

a. The entire cone. *b*. A part of a cone showing the sacs on the scales which bear the pollen. *c*. A single scale.

As you know, the scales of a cone are brown and hard and tough. This is because the spores in the sacs must be well protected from injury, for inside each spore is a tiny bit of living substance, soft and white. The living substance within the spore of the carpel divides many times until a little plant is formed, so small that the spore-wall never bursts because of its growth. This plant never gets out into the air and sunlight, but spends all its life within the dark spore-walls. Two little flask-shaped struc-

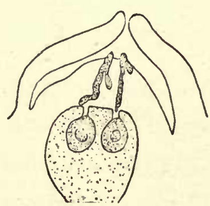


FIG. 124. TWO LITTLE PLANTS IN THE CARPEL OF A CONE, EACH OF WHICH BEARS AN EGG OR MOTHER-CELL

tures form within the body of this plant, and in each is an egg.

While the little plant in the carpel has been growing, changes have taken place within the pollen-grain. This is also filled with living substance, and this living substance divides in several parts. Two of these parts become sperms. These sperms have no tails, as in the fern sperm, so they cannot swim. But little wings grow out on each side of the pollen-grain, and so the wind carries pollen-grain, sperm cells and all about in the air.

FIG. 125. FOUR POLLEN-GRAINS GROWING INSIDE THE SCALE

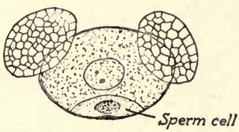


FIG. 126. WINGED POLLEN-GRAIN CARRYING THE SPERM OR FATHER-CELL

The pollen-grains are yellow, and there are so many in each pollen sac that sometimes yellow showers fall upon the mother pine tree, and on all the carpellate cones. The scales of the carpellate cones spread apart, and the pollen-grains slide down their sides and collect in a drift at the bottom. In this way they are brought close to the little plants in which are the flasks with the eggs. The eggs cannot leave the flasks; so each of two pollen-grains puts out a slender tube which grows through an opening in the spore wall and makes

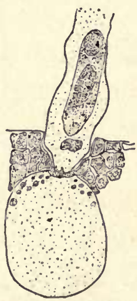


FIG. 127. THE POLLEN-TUBE CARRYING THE SPERM CELL TO THE EGG IN THE MOTHER-PLANT

its way down the neck of the flask close to the egg. At the very tip of each tube is a sperm cell which unites with the egg. As soon as the union has taken place a baby pine tree begins to grow. But the baby pine is still so small that you would not be able to see it without a strong magnifying glass. It is all covered over by the little plant-mother's body, and here it grows and grows.

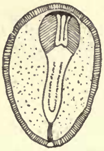


FIG. 128. THE PINE BABY IN ITS CRADLE — THE SEED

After a while a hard, bony covering forms around the mother-plant so that the baby plant has to stop growing for lack of room. The hard, bony covering is a sort of closed cradle, but for years and years people have called it a seed. The seed is the pine baby's cradle, and inside the cradle is plenty of food for the pine baby to eat until it becomes big enough to make food for itself. Before it can grow, however, it must be taken out of its cradle, into

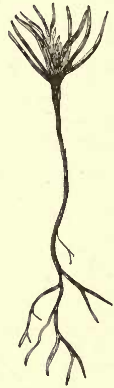


FIG. 129. A PINE SEEDLING

FIG. 130. A PINE TREE GROWING FROM A ROCK

sunlight and moisture, so the cradle loosens from the scale leaf which carried it and drops to the ground. Here the cradle breaks open and the pine baby is free to grow.

At first it feeds upon the store in the open cradle; by the time this is all eaten, little roots and leaves have grown, and now the pine baby is able to care for itself. If the root can strike well into the soil and it gets plenty of water and sunshine, it may grow into a tree taller than your father's house, and strong enough to stand in the fiercest storm. But even if it happens to find itself growing on a rock, the roots manage to crack the rock enough to take hold and keep the little plant in place. Of course, it seldom gets to be so big when it grows on a rock as when it grows in soft earth. But even on a rock it makes the best of a poor situation and tries to live as cheerfully as possible. It is even able to grow in the far north, where the ground is frozen the greater part of the year.

CHAPTER IX

THE CHILDREN OF PLANTS THAT BEAR FLOWERS

So many plants bear flowers, and some of them give us so much pleasure by their beautiful colors and sweet odors, that we almost forget *why* flowers grow and think they are made only that we may pick and enjoy them. When we have learned what flowers really are, we will, perhaps, care more about them and not pick wild flowers idly, only to throw them away.

FIG. 131. FLOWERING PLANTS—THE ROSE AND THE IRIS

All plants that do not belong either to the pine family or to the fern family or moss family, or to one of the other families of plants we have studied, are flowering plants. And there are many thousands of different kinds, each kind having flowers that differ from those of every other kind.

Flowering plants have not always lived upon the earth. Wise people tell us that it took plants a

long time to learn to produce flowers. Mosses and ferns lived on the earth long before there were any flowers. It not only took thousands and thousands of years for plants to learn to make flowers; but after they had once learned this, it took them almost as long to make all the different kinds.

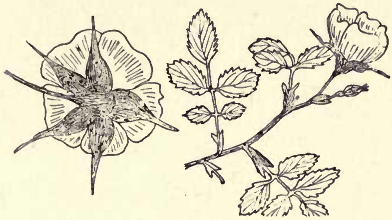


FIG. 132. A WILD ROSE

And how do you suppose the plants made their flowers? In the simplest and easiest way that a plant could possibly do it — by changing its leaves. If you look at the flower of a wild rose, you will see that it is composed of several parts. The stem on which it grows is called the *petiole;* at the end of the petiole is a cup, the *calyx;* growing out from the edge of the calyx are fine, narrow, pointed, green leaves, the *sepals*. As you see, these leaves have not the same shape as the leaves on the stem of the rose-bush. They have become changed in order better to cover the flower before it has grown big enough to bear the sunshine, the showers, and the winds of summer.

FIG. 133. A WILD ROSE IN WHICH THE ARRANGEMENT OF PETALS, STAMENS, AND PISTILS IS SHOWN

A flower that is not full-grown is called a bud. As the parts of the flower grow, the sepals spread apart and open, and we see within delicate, soft,

red, yellow, white, or pink leaves. There are usually five of these in a wild rose, and they are called *petals*. Can you guess how leaves like those on the stem of the rose-bush become soft and red in color like the petals? If you look at the stem and at the petioles of the leaves, you will see patches and bands of red on some parts of them, especially the parts turned away from the sun. This red color is caused by red coloring matter in the plant, just as the green of the leaves is caused by green coloring matter. The red coloring matter exists in every part of the plant, only in the leaves and stem it is covered over by the green coloring matter.

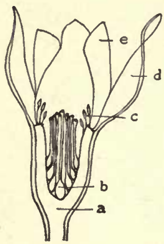


FIG. 134. A WILD ROSE DIVIDED TO SHOW THE FORM OF THE CALYX, AND THE POSITION OF THE PARTS OF THE FLOWER
a. calyx. *b.* pistils. *c.* stamens. *d.* sepal. *e.* petal.

Leaves that do not grow in the light lose their green; and so the petals, being covered over for a long time, gradually lost all their green coloring matter, so that now the red is clearly seen. In losing the green coloring matter, the petals also lost the power to make their own food, and so they are fed and cared for by the green leaves on the stem of the bush. But these petals or red leaves are not the real flowers at all. Most boys and girls think so, and some grown people, too. The real flower

FIG. 135. THE PETALS AND SEPALS REMOVED TO SHOW POSITION OF STAMENS ON THE CALYX

is inside the petals. Here you see a great many little thread-like structures with yellow knobs at the end. There are so many in the rose that it would be hard to count them, and they are called *stamens*, like the structures we found in the father-pine.

FIG. 136. A POLLEN-TUBE CONTAINING A SPERM CELL GROWING TOWARD THE EGG IN THE PISTIL

Then within the circle formed by the stamens are green vase or bottle-shaped structures, each with a long, slender neck, which opens at the top. As you see, each is very much like the structure we found in the pine in which the little mother-plants of the pine tree grew. Each vase-shaped structure in the rose is called, also, an ovary, and contains a little mother-plant. Each yellow dust-particle or pollen on the stamens contains a tiny father-plant. One father-plant must unite with one of the mother-plants before a baby rose can grow. The pollen-grain with its tiny father-plant inside is carried by the wind or by an insect to the tiny flask-shaped structure, and here it is held fast by a gummy substance at the opening of the neck.

FIG. 137. THE HIP, OR RIPENED CALYX, CONTAINING THE SEEDS

A tube grows out from the father-plant, and at the tip-end of this tube is a sperm cell. In the body of each mother-plant is an egg cell. The sperm cell is carried by the pollen tube to

the egg cell, with which it unites, and at once a little rose plant begins to grow. As soon as the little rose plant has been formed, the petals wither and fall, the calyx closes over the pistils, and its wall becomes thickened. After a time it also loses its green coloring matter and becomes bright red. We call this bright-red structure the *hip* or fruit of the rose. Within the hip each little baby rose lies in a firm, closed cradle called the seed, in which there is plenty of food for its nourishment, until the time that it has grown big enough to make its own food.

Fig. 138. A Butterfly getting Nectar from the Flower and taking away Pollen on its Body, which it leaves on the Pistils of Another Flower

The color of the rose petals is of great use to the little mother-plants within the ovary; so is the nectar that is made by the petals and stored away at their base. You see the mother-plants cannot move, but must remain where they are all their lives. Indeed, the only reason they live at all is to give life to another little rose plant. This they cannot do unless the sperm in the pollen-grain of the father-plant can reach and unite with them.

Bees and butterflies see the bright colors of the petals or, perhaps, they smell the nectar; for they fly about from one flower to another all day long to get this. As they step upon the stamens and dip their mouths into the nectar, the pollen-grains cling to the hairs on their legs, and as the bee or butterfly crawls over the flower, some of the pollen-grains are left at the open end of the pistil which contains the mother-plant. Once placed near the mother-plant, the sperm reach it by means of the tube which grows out from the pollen-grain, as we have already learned.

FIG. 139. THE CALYX WITH ALL PARTS EXCEPT THE PISTILS REMOVED

And so all the parts of the flower seem to be very useful to the baby rose. The petals by their color, and the nectar by its sweetness, attract bees and butterflies; the father-plants are formed in the stamens, the mother-plants in the pistils; and when the baby rose plant is formed, the calyx covers and protects it from harm until it can take care of itself in the warmth and sunshine of the spring time.

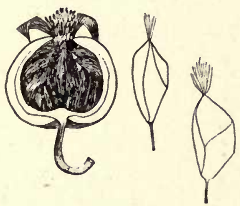


FIG. 140. THE SEEDS IN THE FRUIT OR HIP OF THE ROSE

If pollen from another kind of rose is placed upon the pistil so that a pollen tube can form and carry the sperm cells to the egg, the seed which reuslts from such a union will grow into a rose plant which bears flowers differing from

both mother and father rose plants. A plant which differs in form, size, color, or ways of growth from its parents is called a *variation*, and many of our most beautiful flowers are variations of simpler and less beautiful parent plants.

In many flowering plants Nature brings about such variations by using the wind, insects, or birds to carry the pollen from one sort of flower to another. It often happens that children of flower-variations are stronger and bigger and better able to endure cold or dry weather than were their parents. So the variations live while plants like their parents are killed. Everywhere in Nature those that are strongest or best adapted to the conditions where they must live, survive, and have children who live after them to take their places. This is Nature's way of selecting, and is therefore called *Natural Selection*.

Men and women have observed the results of Natural Selection and have learned how to produce variations for themselves in plants as well as in animals. Wheat, corn, and rice, as well as numerous fruits, have been produced by the selections made by man; so have our garden vegetables and many other plants. Roses are loved by so many people that much attention has been given to producing variations in them. Since variations in all kinds of flowering plants are produced in much the same way that they are in roses, one description will do for all.

First of all, the parent plants are carefully chosen. A poor, weak, scrubby-looking rose plant is not likely to bear large and beautiful roses. So a strong and beautiful plant is chosen for the mother-plants in the pistils of its flowers, and another plant of a different kind, also strong and beautiful, is chosen for the father-plants in its pollen-grains.

Since the mother-plant in the rose unites most readily with the father-plant in the pollen of its own flower, great care must be taken in bringing about a union with a father-plant having a different kind of pollen. So all the stamens on the mother-rose must be cut off before the pollen becomes ripe, and the pistils covered so that no stray pollen can be carried to them by insects or by the wind. When the eggs in these pistils become full-grown, the tube leading to them spreads apart, and the top, or stigma, becomes covered with a sticky substance.

It is now time to get the pollen from the other rose plant. This can be taken from the ripe stamens with a soft little brush and so laid upon the stigma of the pistils. If no other kind of pollen is permitted to touch the stigma, the little rose plant formed from the egg and the sperm cell will be different from its parents and will therefore be a variation, or a new kind of a rose plant.

If the seed bearing this new rose plant is planted in the fall, it will begin to grow the following spring, providing the soil in which it lies is moist. The reason the seed cannot grow without moisture is

that it contains a large amount of a substance called carbon. It is necessary for it to throw away some of this carbon before it can grow, and water helps it to do this.

The little seedling does not look like a rose, and one can never tell if a certain seedling will bear fine flowers until it is quite grown up. Sometimes a poor-looking seedling grows up to be a fine bush and may bear fine flowers. It often takes Nature a long time to complete and perfect her work.

Any one who is willing to exercise patience and care can produce new flowers, grain, or fruit in the same way that new roses are produced.

CHAPTER X

HOW PLANTS BECOME SICK

ALL the plants which we have studied so far have been in good health. But plants as well as people may become sick, and there is always a reason or cause, as we say, for the sickness. A plant which grows in a soil suitable for its needs, and which also gets as much water and sunshine as it needs, usually does not become sick, for it is strong enough to resist its enemies. But if for any reason the food or the surroundings of the plant are not suited to its needs, or if it is cut or bruised in any way, then that plant becomes weakened, so that sickness and even death may follow.

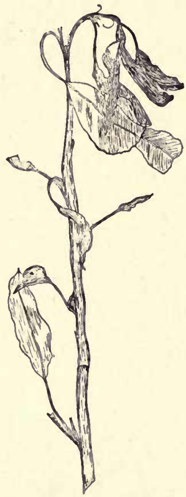


FIG. 141. A PEAR SHOOT BLIGHTED BY BACTERIA

There are four chief causes or reasons for sickness among plants. They may be attacked by bacteria, by molds or plants related to the molds, by flowering plants, and by insects.

Much of the sickness among plants is caused

by bacteria, which attach themselves to the twigs, leaves, flowers, stems, or fruit of plants. Even apple, pear, plum, and quince trees suffer from bacteria. They poison the leaves of these trees so that they shrivel and die; and they also injure the fruit so that it cannot be eaten.

FIG. 142. CANKERS ON A TREE TRUNK

The bacteria which cause the disease live through the winter in sores or cankers which they make on the trunks of trees. In the spring, milky, sticky drops full of bacteria ooze out from these sores. Bees and flies carry the bacteria from the sores to the flowers or growing tips of other trees. Here the bacteria feed and grow and in a week or two all the trees on which they have been placed are sick, and their leaves, flowers, or fruit turn brown.

FIG. 143. A GREEN APPLE AND LEAVES ATTACKED BY BACTERIA

The best way to prevent these bacteria from causing disease among fruit trees is to scrape the sores away from the bark of the sick trees with a knife, and then wash the place with water to which a strong acid has

been added. Sick limbs and twigs should be cut off entirely and burned.

Beans, cucumbers, tomatoes, turnips, cabbage, and many other garden vegetables become diseased from bacteria. When one sick plant is found, it should be destroyed at once to prevent the spread of the disease to other plants; for sickness of one plant usually comes from the bacteria which have made some other plant sick.

FIG. 144. A PEAR SPOILED BY BACTERIA

FIG. 145. THE APPEARANCE OF A PEAR ATTACKED BY BACTERIA WHEN CUT IN TWO

All plants which live upon or within some other living plant are called parasites. A parasite cannot make its own food; it depends on the work of some other plant for food, and if it cannot steal this, it must die.

The bacteria which cause sickness among living plants are parasites; but some other plants beside bacteria are also parasites and also cause disease in the plants they feed upon. Among these are the molds and relatives of the molds called rusts, smuts, rot, or blight. The

FIG. 146. PLUM FRUIT CRIPPLED BY A PARASITE RELATED TO THE MOLDS

names of these parasites tell something of their appearance, or of the appearance of the disease they cause.

FIG. 147. THE LEAVES OF A POTATO PLANT ATTACKED BY A RELATIVE OF THE MOLDS

The spores of these plants are carried by the wind or by insects to various plants, and once on the leaves, buds, or fruit of green plants, they grow and make their way inside, where they live until the leaves may wither and die, or the fruit shrivels and dies. When all the leaves are gone, the plant can no longer make food for itself, so it dies.

All such plants as rusts and smuts are parasites, and have lost the power to make food for themselves. The smuts and rusts are among the most dangerous of these parasites. The smuts live on growing corn-kernels, or on wheat, and cause so much harm that thousands and thousands of dollars worth of these grains may be destroyed every year. The best way to stop the spread of disease is to burn the black spore-masses as soon as they are seen on the corn. But it is better to destroy the spores that may be on the corn-kernels before these are planted. Wheat-smut can be destroyed by steeping the seed

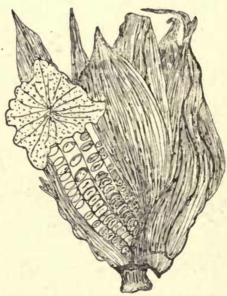


FIG. 148. AN EAR OF CORN ATTACKED BY SMUT

wheat in hot water before planting. This kills the spores and does not hurt the wheat. To keep smut out of corn, farmers should not plant corn in the same fields year after year, but change or rotate the crops.

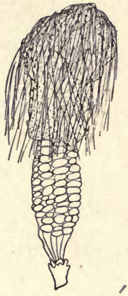


FIG. 149. THE HUSKS REMOVED FROM AN EAR OF CORN TO SHOW HOW THE KERNELS ARE DESTROYED AND DEFORMED BY SMUT

The rusts are colorless plants which cause disease in wheat, oats, barley, and rye. These parasites are called rusts because they form red or yellow streaks or spots upon the leaves and stems of grain. In late summer black spots also appear. The rust parasites cause a loss of many million dollars every year in the United States, and also in Europe and in Australia. Rust destroyed nearly eighteen million dollars worth of wheat in Prussia in one year, and almost forty-five million dollars worth of other grain. The best way to prevent so great a loss of grain is to plant only strong, healthful seed-grain which rusts cannot harm so much.

FIG. 150. RUST ON THE BLADE AND ON THE STEM OF A WHEAT PLANT

FIG. 151. A WITCHES' BROOM

Rusts also live upon and destroy violets, asters,

goldenrod, roses, clover, blackberries, and other plants. One kind of rust causes witches' brooms in trees and shrubs, and cedar-apples on juniper.

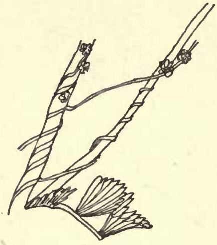


FIG. 152. DODDER

Some flowering plants also fasten themselves on other flowering plants and suck their juices, causing them to lose leaves, twigs, or branches, or perhaps even killing the entire plant. The best known flowering parasites are the dodder and the mistletoe. The dodder first roots itself in the ground, grows a slender stem, leans this way and that until it finds another plant whose juices it likes. Then it twines about this and new sucking-roots grow by means of which it can steal the food made by the other plant.

FIG. 153. AMERICAN MISTLETOE

The dodder is a complete parasite. The mistletoe is only a half-parasite, and sends its roots into branches of the fir, cottonwood, and other trees. The twigs or branches of the tree it lives on die from the point where the mistletoe is placed and outward. In some countries it is necessary to cut off the mistletoe from the trees every year or the trees would die.

Disease in plants is also caused by animals. Of course horses, cattle, and sheep destroy many plants

by eating them. Both animals and man depend upon some plants for food, and some animals are so greedy and use so much plant-food that human beings are obliged to look after their rights carefully, or they might die from starvation.

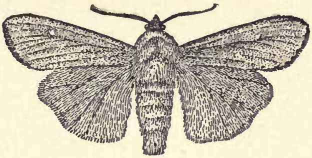


FIG. 154. MOTH OF THE ARMY WORM

The animals that do the most harm to plants by causing disease are the insects and their young. Insects also destroy millions of dollars worth of grain and fruit which are intended for the use of man. It is said that in the United States alone, seven hundred million dollars worth of crops are destroyed by insects. So every body ought to know something about the insects that are injurious to plants in order that so much loss to human beings may be prevented.

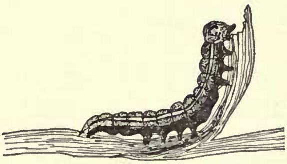


FIG. 155. THE ARMY WORM

One reason that insects, although usually not very large, can do so much harm is because there are so many of them. As far as numbers go, most of the animals in the world are insects. Many insects are not harmful at all; others are useful to plants and to man; and still others are very harmful.


FIG. 156. A CHINCH BUG

Among the insects which cause disease in plants

are plant lice, chinch bugs, potato beetles, scale insects, and locusts. The young of moths, of flies, and of various beetles also cause much damage.

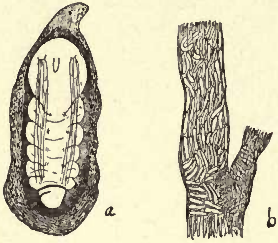


FIG. 157. SCALE INSECTS
a. Mother scale insect beneath a scale. *b.* Scales on a branch.

The best way to prevent much harm to plants and to man from insects is to learn how and where these insects grow and what the young feed on, because it is often impossible to destroy the full-grown insects. The best way to prevent flies from carrying disease is to keep barnyards and stables free from manure in which the eggs of flies grow into new flies, or to destroy the eggs in the manure before they can grow.

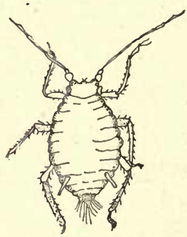


FIG. 158.
A PLANT LOUSE

FIG. 159. APPLE LEAF TUNNELED BY CATERPILLAR

The chinch bug, plant lice, and plant scale suck the juices of the plants they feed upon and destroy wheat, fruit trees, roses, and peas. Other insects also attack forest trees, grapevines, strawberries, and shrubs.

The apple tree and its fruit, which are so highly valued by most people in all parts of the world, seem also to be a favorite with insects. An English writer gives a list of fifty-

seven insects which feed on the apple. Among these insects are butterflies, moths, beetles, sawflies, wasps, plant lice, and plant scales. It is usually the young of these insects that do the greatest harm. Thus the caterpillar of the Eyed Hawk moth and of the Lappet moth may strip the tree of all its leaves. The

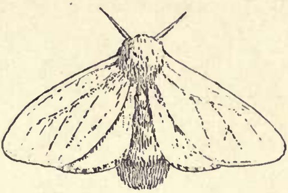


FIG. 160.
A BROWN-TAILED MOTH

Clearwing moth lays its eggs on the trunk of the trees, and when the eggs hatch into caterpillars these dig tunnels under the bark and make deep hollows in the wood, in which to lie while they change into grown-up moths. The Brown-tailed moth was brought to America from France on rose-bushes, and here it lays its eggs on the under side of the leaves of trees and covers them over with hairs from its tail. The eggs hatch into caterpillars which eat the covering of the leaves. Then they make a nest for themselves of dull gray silk and live in this nest all winter. In the spring, they begin to eat the new leaves and buds as soon as these open, and all the leaves of the trees are eaten up unless the caterpillars are

FIG. 161.
A TENT OF YOUNG BROWN-TAILED MOTHS

FIG. 162.
A CODLING MOTH

destroyed. They are called Brown-tailed because while the wings and body are pure white, the tail is covered with golden-brown hairs.

FIG. 163. EGG AND PUPA OF CODLING MOTH

The best way to save apple trees from these moths is to pick off and burn their nests in the winter, when they can easily be seen.

The moth that does the most damage to apples, however, is the Codling moth. It lives in almost all parts of the world, so that whether we get apples from the United States, from Canada, England, Spain, or Madeira, we are likely to find "maggots" inside which make them useless for food. This "maggot" is creamy-white in color, and has six pairs of true legs and five pairs of false legs, and is usually found near the centre of the apple, at the core.

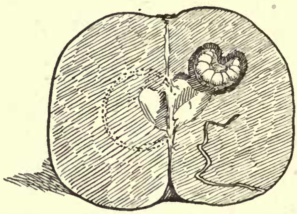


FIG. 164. THE YOUNG OF THE CODLING MOTH IN THE APPLE

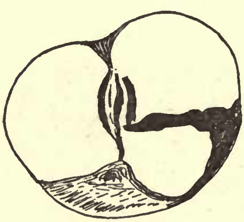


FIG. 165. AN APPLE FROM WHICH THE YOUNG OF THE CODLING MOTH HAS GONE

How did it get in, do you think? Well, before it was a "maggot" it was an egg, of course, and was placed by its mother on the side of a tiny apple just after the blossom had fallen. Here the

egg grew into a caterpillar, which crawled over the apple until it reached the little opening at the top, which is called the "eye." It entered this and began to feed, and also to burrow, until it got to the centre of the apple.

Fig. 166. A Sawfly

Here it remained until it was full-grown, and then it tunneled its way out again at the side and formed a large round hole in the skin of the apple. Then it either crawled out of the apple and down the branches to the ground, or fell directly to the ground. From here it crept up the trunk to a safe place under the bark. Here it spun a cocoon for itself, and after a time it changed into a moth which could lay over one hundred eggs, and therefore was capable of destroying a hundred or more apples. This is the story of the apple-maggot, which is really the young of the Codling moth.

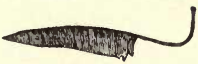


Fig. 167. The Saw of a Sawfly

Beetles attack the stems, twigs, or fruit of apple trees. Sawflies and wasps eat out great cavities in apples, sometimes leaving only the dry skin upon its twig. Plant lice suck the juices from young branches so that these become crooked and deformed and unable to bear leaves and fruit.

Fig. 168. An Apple eaten out by a Sawfly

Unless care is taken and the eggs or young of

these insects destroyed, there will be few apples in the world fit for the use of human beings, and no glorious apple blossoms to gladden the eye in the spring time.

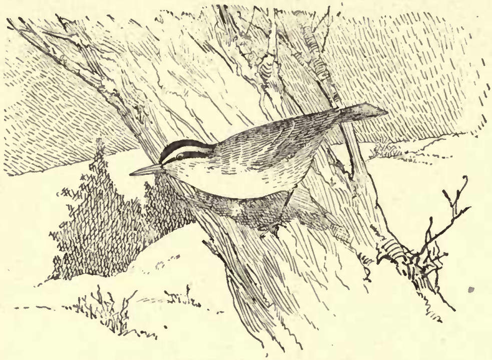


FIG. 169. A NUTHATCH

Of course, not all the eggs of these insects that are laid ever become full-grown insects, for thousands upon thousands of caterpillars are eaten by man's friends, the birds. When the Woodpecker's drum is heard, or when the Blue-tits, Creepers, and Nuthatches pass swiftly up or down the tree trunks, then we may know that many a caterpillar is being destroyed, and that our fruit trees are being saved.

FIG. 170. LEG OF BEE WITH ITS BASKET FOR CARRYING POLLEN

The birds are not able to eat all harmful caterpillars; so farmers and other people learn how to kill them by spraying or even by picking them off by hand.

It would be wrong to think that all insects are harmful. Some insects are of great use to plants by carrying the pollen contain-

ing the sperm cells from one plant to another plant bearing the egg cells. Some pollen is light and can be carried by the wind; but much pollen is heavy and sticky, and so plants depend upon insects to carry this about. The plants pay the insects for doing this work by letting them eat some of the pollen and also the nectar that is made by the plants and kept in little sacs at the bottom of the corolla.

The insects go straight from one flower to another, carrying the pollen on the hairs of their bodies or in little baskets on their legs. Many beetles, all butterflies and moths, and most bees have scales or hairs on their bodies in which the pollen of one flower becomes entangled and then is brushed off when the next flower is entered.

So, while it is well to beware of insects that cause plant diseases, it should not be forgotten that many insects are harmless and that others are very useful.

CHAPTER XI

HOW THE SMALLEST ANIMALS GROW

Of course you know that robins and sparrows and ducks and geese and chickens and pigeons come from eggs. If I were to tell you that horses and cows and elephants and lions also come from eggs, you would perhaps think that I was trying to make you believe a tale stranger than the strangest fairy-tale, or than the story of Aladdin's wonderful lamp. So I shall not say now that they do, but ask you, instead, where you think frogs and toads come from? and lizards? and snakes? and fishes? and lobsters?

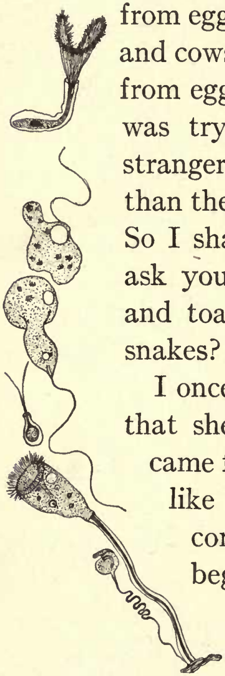


Fig. 171. Some of the Smallest Animals

I once heard a young lady in college say that she "couldn't believe a grasshopper came from an egg, anyway." Would you like to know what a grasshopper *does* come from? If you do, you had better begin to find out where animals very much simpler than grasshoppers come from; for the grasshopper is quite an aristocrat among animals, having six legs, two kinds of eyes, and ears near the middle of the body. Indeed, there is nothing simple about the Grasshopper.

But in the ponds and ditches where we found the thread-plants growing, there we are likely also to find animals which have neither eyes nor ears nor legs — nor any head either, for that matter. The reason you have never seen these animals is because they are so small that one of them cannot be seen without a magnifying glass. A drop of water from a ditch placed upon a glass-plate under a magnifier is a little world in which the living things are tiny, white, irregularly shaped clumps of jelly. Each clump of jelly sinks to the bottom of the drop and moves very slowly over the surface of the glass. If it did not move, you would scarcely suspect that it was alive. But it is made of *protoplasm*, just as are the cells of a plant.

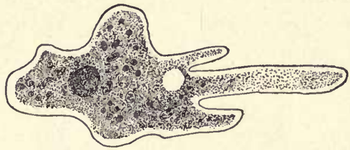


FIG. 172. AN AMOEBA

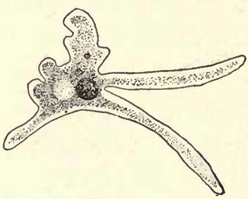


FIG. 173. AN AMOEBA MOVING IN THE DIRECTION OF THE TWO LONG FALSE FEET

This animal consists of only one cell, and it seems to have no covering over it as do the plant cells. Around the edges of its body the living substance, or protoplasm, is so clear that one can almost see through it; but the inner part contains many small grayish granules. Besides the granules there is a large, roundish, dark spot near the centre, called the *nucleus;* and another clear

spot about the same size as the nucleus, called the *vacuole*.

The picture in Fig. 172 shows what the animal looks like, only the picture is more than a thousand times bigger than the animal really is. It is called *Amoeba*, or Amēba, which is a name meaning "change." As you look at it, you see that it moves; and each time that it moves its shape

FIG. 174. THE WAY AN AMOEBA GETS ITS FOOD

changes. Since it has no legs or arms, it must move with the whole body. First one part of the body is thrust out, then the other parts of protoplasm follow until the entire body has changed place. The small projections you see in Fig. 173 are formed by that part of the protoplasm which first begins to move. These projections become larger as more of the body of the animal flows toward and into them, and they are usually called false feet.

Although the Amoeba has no mouth, it eats; and although it has no nose, it breathes. If you watch it, you can see for yourself how it eats. When its body touches a small green plant or a tiny crumb of other food-material, it simply flows around it and surrounds it with its body. No sooner is the food

within its body than the protoplasm proceeds to break it up and take from it whatever it needs. The rest is thrown out into the water again from whatever place in the body it happens to be.

A large Amoeba may even eat a small one. The large Amoeba pursues the little one as fast as it can, and prepares a hollow space in the front part of its body in which to place the little one when this is caught. Then it closes over it with its body and begins to feed on its captive.

Sometimes the little Amoeba is able to move so fast that it gets away from the big one. In the picture you see a race between a big and a little Amoeba in

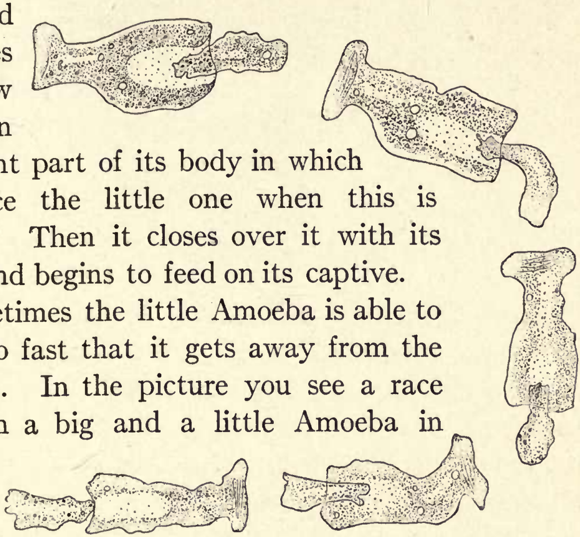


FIG. 175. A BIG AMOEBA TRYING TO CATCH AND EAT A LITTLE AMOEBA

Going — going — gone!
The little Amoeba gets safely away.

which the little one won the race and got safely away!

In watching an Amoeba you would not be able to see it breathe; but if you were to remove the oxygen from the water in which it lives, it would die, just as a girl or boy would die if the oxygen

in the air about them were removed. It has no special breathing part like our lungs, but it breathes with its whole body.

If you were to watch an Amoeba for some time, you would not only see it change its form many times, but you would see it divide its body into two parts, and see each of the two parts move off, perhaps in opposite directions, as if nothing had happened. Each part contains one half of the protoplasm and one half of the nucleus of the mother-Amoeba. No protoplasm can live without a nucleus. That is the way a new Amoeba is born. The mother-Amoeba gives its own body to be divided between two children. That is, out of her body two little Amoebae (*Ȧ-mē-bē*) are formed. The mother does not die, you see, as a bird does if someone should cut it in two. The two Amoebae children use the parts of her body which she gave them when they were born as the beginning of a body for themselves, which each of them must complete. As long as each of them lives, the mother also lives, for a part of her body makes up a part of their bodies. The baby Amoebae are small at first; but they soon grow as big as was the mother-Amoeba before her two children were born.

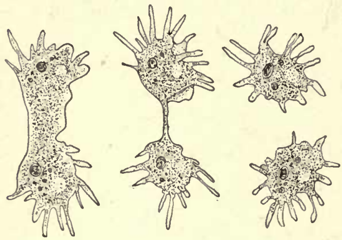


FIG. 176. AN AMOEBA DIVIDING INTO TWO

Amoebae children must take care of themselves from the very first and find their own food, for of course there is no mother left to do this for them. If they get cold or if the water in the ditch or pond where they live dries up, they make a thick wall for themselves and inside this wall they can live a long time without food or water. As soon as the pond fills, the thick wall breaks open and each Amoeba can crawl about and get food again.

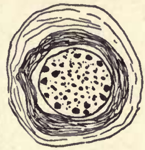


FIG. 177. AN AMOEBA INSIDE A THICK WALL

Most Amoebae are harmless, but some kinds cause sickness if they get into the human body. The disease called malaria is caused by an animal very much like an Amoeba, which grows in the body of

FIG. 178. A SORT OF AMOEBA THAT GETS INTO THE RED BLOOD CELLS OF HUMAN BEINGS AND CAUSES MALARIAL FEVER

a. The Amoeba soon after it has entered the blood cell. *b.* The Amoeba has divided itself into many small parts, each part able to grow into a new Amoeba. *c.* The shattered blood cells permit the little baby Amoebae to escape, so that each can grow and enter another blood cell. *d.* The appearance of the grown-up Amoeba.

a mosquito. When the mosquito bites a person, these little creatures pass from the mouth of the mosquito into the blood. From the blood they make their way into the red blood cells, which they destroy by breaking them up, as you can see in Fig. 178*c*. Then each young Amoeba enters another

red blood cell, and pretty soon most of the blood cells in the body will become broken up unless some good doctor gives the person medicine to stop the growth of the animals.

Besides Amoebae, there are many other wonderful creatures living in ditches and ponds. They are so small that hundreds of them may be seen in a single drop of water. One of these is the *Difflugia.* The Difflugia has a more definite shape than the Amoeba because it sticks grains of sand, bits of glass or shell, to the outside of its body, leaving only a small portion uncovered, from which it projects parts of its body in moving, in the same way as does the Amoeba.

FIG. 179. A DIFFLUGIA

It eats, digests its food, and breathes in the same way that the Amoeba does. But it differs from the Amoeba in that although it is so small, it makes a covering for its baby before it sends it away. Instead of dividing its body into two equal parts, it takes up bits of sand and shell and builds a new covering over a small part of its own body. Into this part it sends a portion of its nucleus. When all is ready, the small part is separated from the mother, and it goes off to live and grow up to be just like its mother. Such animals as the Amoeba and Difflugia seem to enjoy living in glass jars in the house, and from these they can be taken and studied all the year around.

Another little creature that seems to live as happily indoors in a jar of water as out-of-doors in a pond is the Slipper animal. From the picture you can see why it is called the Slipper animal.

This animal has a covering made not from sand or shell, but from the living protoplasm of its body. This covers its body as the skin covers our bodies and is called the cuticle. As you see, there are little hair-like projections all over its body. These are placed in rows, and are used to help the animal turn round and round and to dart through the water very rapidly. Besides these short hairs (which are not real hairs at all, but fine extensions of the substance of the body), there are long, whip-like structures which usually lie coiled up in little sacs just inside the cuticle, but which quickly uncoil and strike any object which may prove harmful to the *Par-a-moe'ci-um*, or Slipper animal.

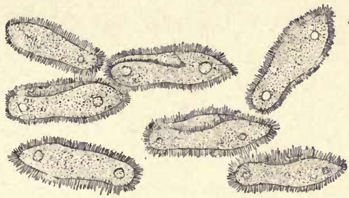


FIG. 180. SLIPPER ANIMALS

Near the end which is foremost when the Paramoecium moves, there is a sort of dent or cavity. Through this cavity the food passes into the animal's body. In the interior of the body are two portions of protoplasm which look darker than that surrounding them. One of these portions is rather large and shaped almost like a bean. The other is small and round and lies near the larger one. Both

are nuclei, and necessary to the life of the animal. Near each end of the animal, also, is a round, clear spot which grows bigger and bigger until at last it seems to disappear altogether, like the light of a candle when it is blown.

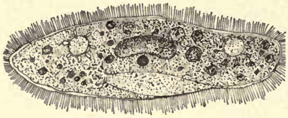


FIG. 181. A SLIPPER ANIMAL GREATLY ENLARGED TO SHOW ITS PARTS

In some animals, tiny clear sacs surround the larger round body and open into this. All these clear spaces seem to contain a watery fluid; but they are, nevertheless, called vacuoles, or *empty spaces*. It is thought that these vacuoles help the animal to throw out waste fluids from the body. When the food materials have been taken into the body, they are carried by the protoplasm round and round until they are digested. The solid waste is thrown out of the body at a place just back of the mouth-cavity.

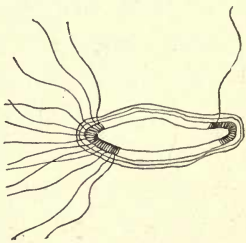


FIG. 182. A SLIPPER ANIMAL WITH ITS LONG, WHIP-LIKE LASHES THROWN OUT IN DEFENSE. EACH CAN BE COILED UP IN A TINY SAC

By a stretching and then a pulling together of the protoplasm, and by the rapid movements of the hair-like projections or cilia over its body, the Paramoecium moves forward rapidly, and moves up and down and round and round in the water in which it lives.

Like the Amoeba, the Paramoecium divides its own body into two equal parts to give birth to two

children. These children soon grow up and each of them divides its body into two parts. Their children do the same thing when they grow up; and so the division may continue until from the first animal hundreds of thousands of animals have formed. Division goes on so rapidly that this number may form within a short time. But now the grown-up Paramoecia seem to become small and weak. They move less rapidly than before.

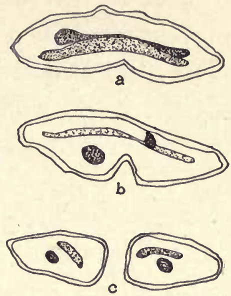


FIG. 183. A SLIPPER ANIMAL DIVIDING
The Nucleus Divides First.

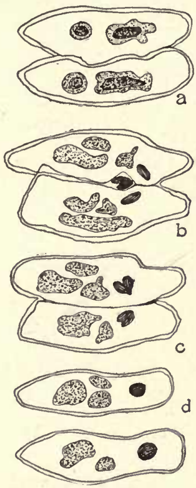


FIG. 184. TWO SLIPPER ANIMALS EXCHANGING A PART OF THE NUCLEUS

Then a strange thing happens. They seem to look about among their mates for somebody to which to attach themselves. In swimming about they seem not to be attracted to some of their kind, but follow others about. At last two of them swim very close to each other until their bodies touch at the foremost ends. They remain close together for sometime. During this time, the small round nucleus in each divides into two parts. One of these parts crosses over into the body of the other Paramoecium and unites with

the part of the nucleus that has remained in its place. In this way each of the two Paramoecia receives a part of a nucleus from the body of another Paramoecium. When this union of the nuclei has taken place, the two animals separate, swim off, and soon divide to form new Paramoecia. These new Paramoecia grow up to be strong, and their children are

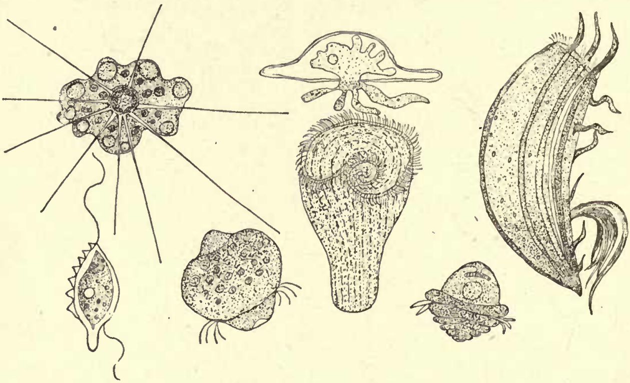


FIG. 185. VARIOUS KINDS OF SINGLE-CELLED ANIMALS

strong, and so all the children that are born, until many thousands have formed by division again.

Most Paramoecia unite with mates to exchange nuclei in order that they may be saved from weakness and perhaps death. And so the story is repeated over and over again. Not that the Paramoecia realize that they become weak or need to be saved, but Mother Nature directs them to do these things for the good of all their kind.

Sometimes two Amoebae or two Difflugias unite in somewhat the same way, but no one knows if

they exchange nuclei. All these animals possess only one cell. No cell can live without a nucleus. An exchange of nuclei in some cells seems to make these cells stronger and more able to form new cells.

In Fig. 185 are seen pictures of several other kinds of one-celled animals. The children of all these creatures are formed by the division of the body of the parent animal, and in most, if not all of them, interchange of nuclei takes place at some time during their life history.

CHAPTER XII

THE HYDRA AND ITS CHILDREN

You have heard of Hercules, the wonderful hero who is said to have lived in Greece thousands of years ago. You will remember that he was so strong that he could strangle a lion with his hands, and so noble that he chose Goodness instead of Pleasure for a companion through life. At the time he lived, the people about him believed that in the marshes and shallow lakes near them lived a terrible monster. This monster was called a *Hydra*, and was said to have the body of a huge serpent, on which were placed many heads — some said seven, others nine, and still others fifty or a hundred. These heads contained a deadly poison, and as soon as one was cut off it grew out again. So, of course, the people greatly feared this Hydra and the king commanded Hercules to kill it. This Hercules did with the help of his friend Iolaus.

There are no such Hydras living now; but in ditches, ponds, lakes, and rivers, tiny little creatures like those you see in the picture are found clinging to bits of grass or weeds. No one would think of fearing these little things as the Hydra of old was

feared; but they also are called Hydra. They are very small, usually about a quarter of an inch long, and very slender. They may be brown or green in color, and some of them are almost colorless.

FIG. 186. HYDRAE CLINGING TO WATER PLANTS

The body of the Hydra is so soft that when the animal is the least bit disturbed it can draw its entire body together into a tiny ball. One end of its body carries six or eight arms or tentacles. These tentacles help the Hydra to seize its food and carry it into the mouth, which, you may see, is in the centre of that part of the body where the tentacles grow out. The mouth is the only opening into the body, for the body is simply a living tube, open at one end, and the tentacles are little tubes closed at the outer end and opening into the bigger body tube.

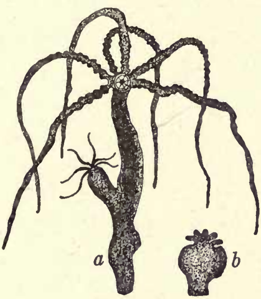


FIG. 187.
HYDRA ENLARGED
a. Extended individual with a young Hydra growing out from its side. *b*. A Hydra which has drawn itself together.

The walls of these tubes are made of a great many cells, closely adjoining, and arranged in two layers, with a soft jelly-like substance between them. All the cells of the inner layer help in the digestion of the food.

The cells of the outer layer are smaller and not quite so soft as those of the inner layer.

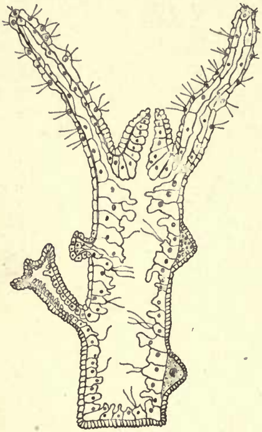


FIG. 188. A HYDRA GREATLY ENLARGED TO SHOW THAT ITS BODY-WALL IS BUILT OF TWO LAYERS OF CELLS

Two buds have formed from its left side which will grow into young Hydrae. On the right side are little sperm cells and an egg cell.

Among the cells of the outer layer are found, here and there, groups of very small cells. At certain times of the year these small cells increase greatly in number by division, and those of one group near the place where the tentacles grow out remain small, and are called *spermatozoa*, or father-cells. In a group of cells near the lower part of the Hydra only one cell grows, and this increases very much in size to become the mother-cell, or *ovum*.

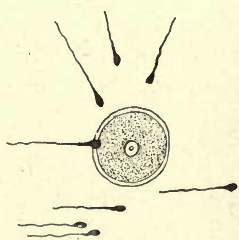


FIG. 189. AN EGG OF HYDRA AND MANY SPERMS. ONE SPERM IS UNITING WITH THE EGG

When the father-cells, or spermatozoa, are full grown, the wall of cells about them bursts open and they fall into the water. Some of them are carried in the water to the place where a mother-cell is also full grown. The father-cell makes its way to the mother-cell and unites with it. Then the parent-cell covers itself with a thick coat, leaves its place in the wall

of the Hydra, and drops off into the water. Here it lies all winter. In the spring the hard coat cracks, and a tiny baby Hydra begins to grow. It soon becomes big enough to attach itself to some weed or stick, and appears just like the Hydra from which it came.

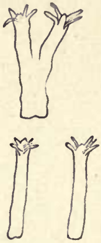


FIG. 190. TWO PARTS OF A HYDRA WHICH HAVE COMPLETED THEMSELVES

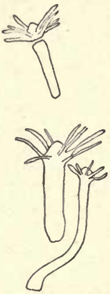


FIG. 191. NEW TENTACLES AND A NEW BODY FORMED

You will remember that the Hydra of the Greek legend was so difficult to kill because each of its heads would grow out as fast as it was cut off. The little Hydra which we have now learned to know is not at all difficult to kill. You can crush it with your little finger. But if you take a sharp knife and cut it into two pieces, each piece will grow into a complete Hydra. Yes, even if you were to cut off *all* of its tentacles instead of only one, every tentacle would grow out again. Is not the real living little Hydra of today even more wonderful than the Hydra of the Greek legend — the Hydra which it took two men to kill, and one of these men was the strongest man in the world?

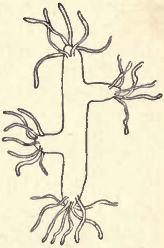


FIG. 192. A MANY-HEADED HYDRA

CHAPTER XIII

WORM FAMILIES

DURING many long years the worm has been looked upon by many people with fear or dislike. But it sometimes happens that people fear or dislike the things they know little or nothing about, and the dislike vanishes with knowledge and acquaintance. So I think when you have learned that most worms are harmless to man and some are really helpful, you will become interested in them, and find that some of them are also really very beautiful.

Worms live both in water and in the earth. Some worms have learned to live in fresh water; but very many live in the salt waters of the ocean, or in the sand along the seashore. Worms that live in the ocean often make themselves curiously shaped houses or tubes to live in, so as to protect themselves from enemies. Some make tubes of lime, others of a substance like thin horn. They begin to build these tubes when they are young, and as they grow the tube is made larger.

They pay for their safety from enemies, however, by becoming unable to move from place to place.

Once the tube is built and fastened to a rock, there the worm must remain. Since they cannot move, they do not need any feet, and so their bodies are smooth except at the head. Here the corners of the mouth have grown into great plumes, yellow, red, green, or white, which surround the head and make it look like a beautiful flower. These plumes are used to breathe with, but can be drawn

FIG. 193. TUBEWORMS WHICH LIVE IN THE SEA

into the tube and the opening closed with a stopper made of material like that of the tube. Besides being the lungs of the worm, these plumes are used to feel, and even to see with, for they may bear twenty or more eyes. As they wave about they make currents of water flow toward the worm, and these currents carry small animals and plants which the worm eats. This is the reason the worm does not need to move to get food. The food is carried to it by these currents of water.

In the mud and sand of the seashore lives the sandworm, in a burrow made of thick black slime. The sandworm is from a few inches to two feet long and has numerous bristles along the sides of its body, which help it to move over the sand, or to swim on the surface of the water. The sandworm usually remains in its burrow during the day, and looks about for food at night. It is worth while to remove one from its burrow in the daytime, however, for it looks beautiful as it moves rapidly away, shining red and green in the sunlight.

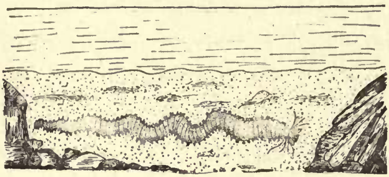


Fig. 194. A Sandworm

Tubeworms and sandworms are beautiful. But in the earth, everywhere, north and south and east and west, live worms which are not at all beautiful, but which are very useful to man. These worms are called Earthworms.

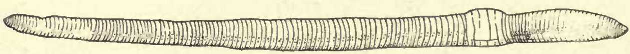


Fig. 195. An Earthworm

When you are on your way to school some morning after a heavy rainfall, you may see, along the roadside or on the grass, many brownish or grayish worms. Long ago people fancied that these worms had come down with the rain from the clouds. But

when, after a time, thoughtful people looked carefully, they discovered that the worms had been washed out of the earth by the rain, and so they called them earthworms. And that is a fitting name; for not only does the earthworm make its home in the earth, but it eats earth, as well as leaves, bits of grass, and even meat. The earthworm has no teeth, but in its mouth is a fluid which digests leaves and other things. When this fluid is poured upon a green leaf, the leaf turns brown.

The earthworm burrows at night, and the opening to its home is closed with a bit of leaf or a small pebble. You can easily find its house if you scratch the surface of the ground over a small space on your lawn. When no rain falls for a long time, earthworms burrow very deep, sometimes several feet below the surface of the earth, or until they reach a moist place. This is because they cannot breathe unless the skin is kept moist. On the other hand they drown if kept in water too long, because water has not so much oxygen as air. In winter they live still further down, so deep that the frost cannot hurt them.

A very wise and learned man studied earthworms for many years, and he concluded that in the fields about the place where he lived, fifty thousand earthworms had their burrows in each acre of land. Do you know how much an acre of land is? Ask your teacher if the school grounds cover an acre? Then ask your father if the lawn about your house

contains an acre of land. If it contains only one half of an acre, how many earthworms may possibly live in it? If it contains three acres, how many earthworms, probably? The more earthworms there are in your father's lawn or in the school grounds, the better for both. For the earthworms carry the earth from below upward, and make the earth soft and pliable, so that plants can easily strike their roots into it and get nourishment.

Earthworms bring up so much earth in one acre of space during one year, that it would fill eighteen big wagons full if somebody were to cart it away. But since they work slowly and carry up only a little at a time, no one thinks of the great work they do. Of course, one earthworm working alone is not able to do much; but because thousands work together, they accomplish much.

The earthworm does much work useful to man, although it has neither head, nor hands, nor ears, nor eyes! Perhaps you have already observed that it usually moves with the blunt and thicker end of its body forward. This end is therefore called the head. The mouth is located on the under side and near the tip of the head. But how can such a legless creature move? Watch it and see if you can discover how. Does it ever move backward? How does it know where to go, since it has no eyes? It feels the light through the skin on its head end, just as a boy or girl feels it when it falls on the eye; but the earthworm is probably not able to tell one

object from another, as the boy or girl with eyes can. So, too, boys and girls usually like to play in the light, and fear or dislike the dark. But the earthworm crawls away from the sunlight, as well as from light of any kind, and tries to hide in some dark place. It is only at night, after the sun has gone down, that the earthworm comes out from its burrow.

You will remember that the body of the Hydra is like a simple tube; but the body of the earth-

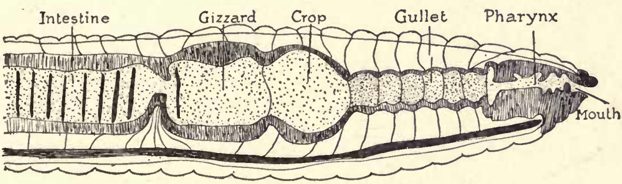


FIG. 196. THE FOOD TUBE OF AN EARTHWORM AND THE RINGS OR SEGMENTS INTO WHICH ITS BODY IS DIVIDED

worm is like a double tube — that is, one tube within another. The outer tube is the body wall; the inner tube is the food-canal. Can you see a reddish streak or line in the middle of its upper surface? That is a vessel filled with blood. Not far from the middle region of the worm is a broad band or girdle. I am afraid you cannot discover for yourself, just now, why the earthworm wears the girdle, so I must tell you that this is really the place where the cradle for its young is made. "But how do the young ever get into it?" you ask. Before you can understand that,

it will be necessary to learn something more about the parts of the earthworm's body.

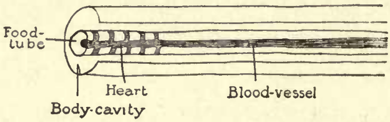


FIG. 197. THE HEART IS MADE UP OF FIVE TUBES WHICH SURROUND THE BIG FOOD-CANAL

The heart sends a large tube backward with blood for all parts of the body.

As you already know, the earthworm's body is made of two tubes, one within the other. One is a food tube, the other the body tube. In the space between these two tubes, and on either side of the food tube, are little sacs containing tiny eggs. In front of the egg sacs are little bags containing sperm cells. You will remember that eggs are mother-cells and sperms are father-cells. Each earthworm carries both kinds of cells, just as does the Hydra; only in the Hydra they are near the outside of the body, and in the earthworm they are inside the body wall.

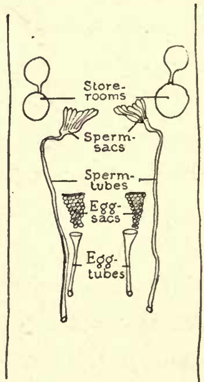


FIG. 198. THE EGG AND SPERM SACS TOGETHER WITH THE TUBES WHICH CARRY EGGS AND SPERMS OUT OF THE BODY

Also the little roundish storerooms for the sperms that have been exchanged.

When the sperm cells are ripe they fall into little tubes which lie open beside them, and are carried by these tubes to the outside of the body, and so placed in little sacs or storerooms in the body of another earthworm.

Every earthworm must exchange sperm cells with some other earthworm. Then the sperm cells remain in the storerooms until the eggs are full grown in the egg sacs. There are not so many egg cells as sperm cells, so the eggs must be cared for and not lost, and they are carried in tubes to little storerooms in another part of the body of the earthworm. For eggs are never exchanged by earthworms as are the sperms, but are placed in a cradle when they leave the storerooms in the body of the worm.

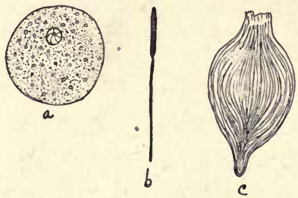


FIG. 199. AN EGG (*a*) and a sperm (*b*) of the earthworm; and the cocoon (*c*) or cradle in which the baby earthworm grows.

And this is the way the eggs get into their cradle: they are pushed out of the egg sacs which we have called storerooms, and into tubes which carry them to the outside of the body. At the same time an elastic band is made by the skin about the girdle, and this elastic band is the cradle. As the eggs approach the two openings in the body walls, through which they leave the body, the elastic band or cradle slips along toward the head just in time to catch the eggs as they come; so that instead of falling on the ground, they fall into a cradle and are carried by it to the two openings or doors of the storerooms where the sperms are kept. Then the sperm cells come out of the storerooms, fall into the cradle, and one sperm cell unites with each egg cell. Then the cradle closes

up so as to cover the eggs entirely, and looks almost like a little grain of wheat.

The cradle is then placed in the earth. If you were to open it after three or four days what do you think you would find? Eggs and sperm? Not at all, but tiny little wriggling worms! For every egg to which a sperm was added has grown into a worm, and the eggs which did not unite with a sperm have been eaten by the little worms. In a short time all the little worms leave the cradle and begin to eat and to dig in the earth just as their parents did. So you see, the mother-worm provides a cradle for her young, and then she leaves them in it to care for themselves.

Some worms are much smaller than the earthworm and as slender as a thread. Because they are so small and slender they are able to live in all sorts of queer places. One of these worms is sometimes called the "Vinegar eel." Its body is smaller than the head of a pin, and it lives in various kinds of mold that grow in vinegar or other fruit juices. The body of the vinegar eel has a tough covering which protects it from being harmed by strong vinegar. Eggs are formed in little sacs inside the body, and in these sacs the eggs grow into little worms like the mother-worm. After they are born they take care of themselves from the very beginning, and never have any other cradle than the egg sac in which they grew inside the mother's body.

Another thread-like worm is often called the

"Horse-hair snake," because for a long time some people believed that if a hair from a horse's tail fell into a pool of water, it would turn into a thread-snake like this worm.

Of course, everybody knows now that such a thing never could happen. But the changes that take place in the life of this threadworm are as wonderful as anything you can imagine. The full grown worm finds its way into some pool, pond, or watering trough, and here it lays its eggs in the water. These eggs grow into little worms which bore their way into caterpillars or the young of insects. These insect young are in turn eaten by a spider or beetle. But the young worm does not die. It crawls out of the young insect and makes its home for a time in the body of the spider or beetle. Here it grows big enough to care for itself, and then it leaves the body of the spider, crawls about until it reaches some standing water, where it lays its eggs, and then another family of young worms repeats the experience of the parents.

Yet another threadworm lives in the muscles of the pig, rat, or of man. The mother-worm lives in the intestine, or food tube, of these animals. The eggs in her body grow into little worms, and as soon as they are born, they bore their way through the intestine to the muscles of the legs or body of the animal. Here they come to rest and make themselves a thick, tough covering within which they lie until the animal they live in is killed and eaten.

Then the covering bursts, and the young worm becomes full grown in the food tube of the second animal in which it lives.

If the animal in which it first lived was a pig, then some human being may eat this pig's flesh and so get the worms into the body. This has sometimes happened in the past, and the people who have eaten such pig's flesh have become very sick with a fever caused by the presence of these animals, and some people have even died as a result. So laws have been made in many countries forbidding the sale of pig's flesh containing these worms, and men are employed to examine pork with a magnifying lens before it can be sold to the people. A good way to become certain of escaping injury by these worms is to cook the meat very well before eating it. This threadworm is called Trichina.

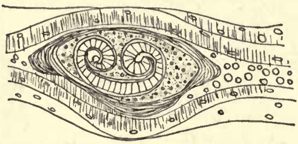


FIG. 200. A DANGEROUS THREADWORM IN THE MUSCLES OF A PIG

Many worms are like neither the earthworms nor the threadworms. If you will look under rocks and sticks in a brook or pond, you will find, clinging close to the rocks, little, flat, leaf-like creatures, so dull in color that it takes a sharp eye to find them in the mud or slime that covers the rock or stick. They are seldom more than half an inch long. Like the earthworm, these worms have no real head; but one end bears eyes and little slender arms which

are called tentacles. The mouth is on the under side of the body, and nearer the tail end than the head end. They remain hidden during the day, but at night they glide about or swim through the water from place to place in search of food, which consists of small worms, snails, crabs, and insects. These worms have a simple brain, and two eyes with which they can tell light from darkness, and they are called Flatworms.

FIG. 201. A FLATWORM

The young of the flatworms grow in some such way as do those of the earthworm, and most flatworms also make a cocoon, or cradle, for their young.

There are many other interesting worms to be found, but among them perhaps it is most important to learn something about the Leeches and the Tapeworms. A leech has a flat body; but unlike the flat-worm's, the body is made up of rings. The mouth is surrounded by a sucker and another is located at the hinder end of the body. All leeches get their food from other living creatures by sucking, and so they are often called "blood-suckers." All leeches are not "blood-suckers," however, for one kind of leech sucks the juices of plants that grow among stones and sticks at the bottom of streams. But most

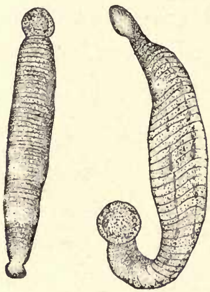


FIG. 202.
TWO LEECHES

leeches attach themselves by the suckers to fishes, frogs, turtles, cattle, horses, and even to man. They cut the skin open with their strong jaws and then suck the blood. When they have gorged themselves, they fall off, and it takes them from two months to a year to digest each meal.

Some leeches lay their eggs in cocoons like the earthworms, and place these cocoons under sticks and stones to be safe from enemies. Others fasten the eggs to the under side of the body, where they grow into young leeches, and remain for many days, holding on to their mother's body by their hind-end suckers.

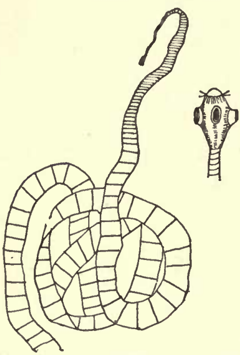


FIG. 203. A TAPEWORM

A Tapeworm has a flat body with a very small head. The body may be only a few inches long, or it may grow to a length of fifty feet. The head has a great many hooks, spines, and suckers, and with these the worm attaches itself to the intestine of some animal. Here its body floats free, and absorbs the food on all sides, for it has no digestive or food tube in its own body, so it depends upon the food digested by its host.

Eggs and sperms grow in each division of its body, however, and as soon as these are full grown one sperm unites with each egg and so a new worm is formed. This becomes enclosed in a thick cover-

ing, but it does not become full grown, however, until after it has passed out of the food tube of one host and into the food tube of another. Then the covering of the young worm is dissolved, and the little worm bores its way through the wall of the intestine and into the muscles of its host. If the host happens to be a pig or a cow, then its flesh may be eaten by some human being, and so the worm becomes full grown in the intestine of this person.

A tapeworm is not so dangerous to the life of a human being as the little threadworm *Trichina;* but it causes illness and great distress since it takes the food that the person ought to have for his own nourishment.

CHAPTER XIV

CRAYFISHES AND THEIR CHILDREN

THE living crayfishes one sometimes sees indoors are kept in glass jars or in an aquarium; and everybody knows that one cannot dig holes in a glass jar or in an aquarium. But crayfishes out of doors live in creeks or rivers, and here they can dig burrows in the soft earth of the banks. Sometimes these burrows are only a few inches deep; but burrows are sometimes found so deep that you or your father could stand erect in one, provided you could get into it. For the burrows are not much wider than the body of the crayfish, and that you know is not much wider than your thumb.

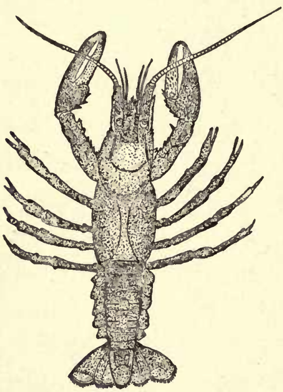


FIG. 204. A CRAYFISH

In winter the burrow is made deep enough to keep the crayfish from freezing, although it does not sleep all winter, as frogs and snakes and bears do. Just as soon as the frost is out of the ground,

the crayfish comes out of his burrow and rushes about to find something to eat. For after being without food most of the winter, you may understand that he is very hungry indeed. Often a crayfish can be seen lying near the opening of the burrow, with only the big claws, feelers, and sharp eyes outside; for whenever an insect, a bug, or a baby fish comes along, out fly the claws and seize it and carry it to the mouth.

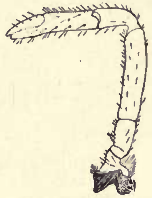


FIG. 205. A WALKING LEG

Crayfishes are never found in dry, rocky countries. Can you tell why?

Everybody knows that a crayfish is not a *fish* at all, but a creature more like a grasshopper than a fish. A real fish has bones inside its body; but a crayfish has no bones at all. Instead it has a hard, horny covering on the outside of its body. A fish has fins, and a crayfish has a great many legs which are jointed so that they can move in many directions. Its body is jointed, too, so that the hinder part can be folded up like a roll of paper.

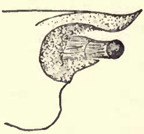


FIG. 206. THE EYE OF A CRAYFISH

The front half of the body is covered by a stiff shield, so that it is not easily moved, but when one looks on the under side of the body, one sees that it also is divided into joints. Its tail, too, is in three parts, and looks like a spread-out fan. Even its eyes are placed on jointed stalks which move

in all directions. Instead of having one eye on each stalk, there are hundreds of tiny little eyes, so close together that they look like one circular brown patch at the end of the stalk. Of what use is it to the crayfish to have its eyes on stalks? Would you like to have your eyes on stalks?

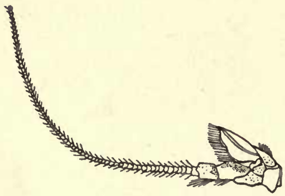


FIG. 207.
ONE OF THE FEELERS

Just behind the eye-stalks two long, whip-like structures are seen. These are feelers. The feelers help the crayfish to discover objects which may prove helpful or objects which are harmful to him.

Usually the crayfish moves forward by walking with four pairs of legs. The fifth pair end in large pinchers for catching food, and are not of much use in walking. They are held straight out in front, and sometimes the pinchers seize hold of the ground over which the crayfish moves, and so hold on till the body moves forward. If the crayfish becomes frightened it moves backward instead of forward. The tail and hinder part of the body are then rolled up, the pinchers strike the ground, and the body bounds backward like a rubber ball.

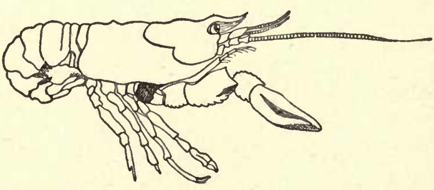


FIG. 208. A CRAYFISH MOVING BACKWARD

The crayfish can walk backward, too, without rolling up its body.

Somewhat like a real fish, the crayfish breathes by means of gills. Each gill is like a feather in appearance; but inside each are many tubes or vessels containing blood, and these take up oxygen from the water in which the crayfish lives. But you will wish to know about the crayfish children and how they can be cared for by such curious parents.

FIG. 209. THE FEATHER-LIKE GILLS OF A CRAYFISH

The mother-crayfish is a very good mother, indeed, and carries her babies about with her, securely fastened to the under side of her body. There you may see them in May or early June, before they leave her to begin life for themselves.

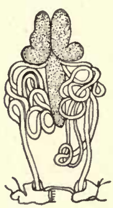


FIG. 210. THE STRUCTURES WHERE THE SPERMS GROW AND THE TUBES THROUGH WHICH THEY PASS OUT OF THE BODY

And how many children do you think there are? Two or three? Oh, no, but two or three hundred! And what do you think they all come from? From tiny little bits of living substance, of course, and they grow in a wonderful way.

Inside the body of the father-crayfish is a structure which looks something like three little crumpled beans, two of which are side by side, and the third underneath the other two.

In these three bodies cells grow which, when full grown, look like tiny wheels without a tire. These cells pass down through tubes that are greatly coiled about each other, and which open on the fifth leg. In the spring, after the crayfishes come out of the ground, the father-crayfish pours the sperm cells over the body of the mother-crayfish, and many become fast to her swimming-paddles, legs, or other parts of her body.

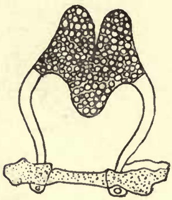


FIG. 211. THE STRUCTURE WHERE THE EGGS GROW AND THE TUBES THROUGH WHICH THEY PASS OUT OF THE BODY

While the sperm cells have been growing inside the body of the father-crayfish, egg cells have grown inside the body of the mother-crayfish. At first these grow in a three-cornered structure, and from this they pass into tubes which lead to the outside of the body. Once outside, they are held fast by the swimming-paddles of the mother-crayfish, and each egg unites with one sperm cell. Then it begins to divide, and to grow larger, and before long a little crayfish is formed out of it.

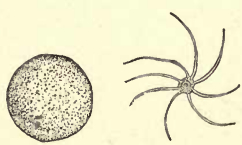


FIG. 212. EGG AND SPERM OF CRAYFISH
Greatly magnified.

All the little crayfish remain attached to the mother's body for many days, and while they are here they change in appearance several times. At first each looks like a little round white ball; later, the ball becomes an oval, with curious pouches on its surface. Then this

changes into the funniest kind of a creature, with what seems to be a large head, and a little tail, and eyes as big as saucers. Next this little creature is changed into one that looks somewhat more like its father and mother, and then a shell forms.

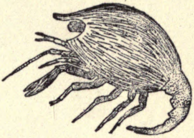


FIG. 213. A BABY CRAYFISH

The little crayfish keeps on growing inside his shell, and every time he gets too big for the shell this drops off, and at last the little creature which came from the egg has become a full grown crayfish, and is able to crawl away or to burrow just as did his father and mother before him.

CHAPTER XV

THE GRASSHOPPER FAMILY

THE Grasshopper is a fine fiddler and he plays at the insect parties given in the evening after the sun goes down. The delightful thing about his fiddling is that he is never obliged to take lessons, he is always in practice, and he carries his fiddle about with him wherever he goes.

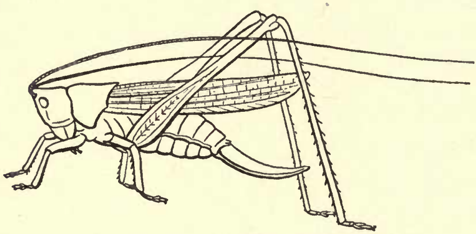


FIG. 214. A GRASSHOPPER

As you know, the grasshopper has two thin, delicate wings, and two other heavier wings which cover the delicate ones when the grasshopper is at rest. The heavy wings are therefore called wing-covers. Near the place where the wing-covers are attached to the body there is in many grasshoppers a roughened portion on the outside, which is the string of the fiddle. There is a sharp edge on the inside of the hind legs. This is the bow. By rubbing the bow upon the string, grasshopper

music is made. Green grasshoppers use the sharp, rough parts of the wing-covering as fiddle and bow.

Most people like the music of the grasshopper. In South America one kind of grasshopper is kept in cages as we keep canary birds, for the sake of its music. But all grasshoppers do not produce the same kind of music. It differs just as does the song of birds. One kind of grasshopper makes music which sounds like a song with the words, "Katy-did, Katy-did; Katy-did — she-did-she-did." This song is sung by day or night. The night-song is also heard on cloudy days. Everybody calls this grasshopper *Katy-did*, and it is bigger than most grasshoppers.

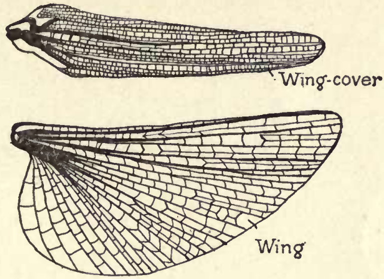


FIG. 215. A WING-COVER AND A WING OF A GRASSHOPPER

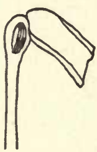


FIG. 216. THE EAR OF A GREEN GRASSHOPPER

The father-grasshopper is the only one in the family that fiddles. The mother-grasshopper has ears to hear it with. And where do you think these are? On her head, of course? Not at all, but near the middle of each of

FIG. 217.
a. Wings and hind legs of locust removed to show position of ear. *b.* The ear greatly enlarged.

her front legs, so that instead of turning her head to listen, she need only stretch out her leg, or move it backward or forward. The ears enable her to hear many other sounds beside grasshopper music, so that enemies are not often able to get too near.

The ears of the Locust are at the sides of the body, just below the trunk. The locust is a near relative of the green grasshopper, but most people seem to

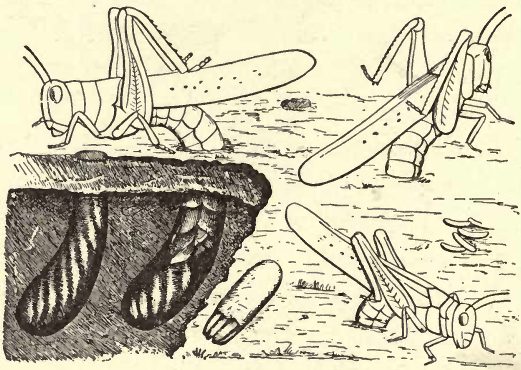


FIG. 218. GRASSHOPPER LAYING EGGS

see little difference in their appearance. The true locusts do resemble green grasshoppers, yet one who looks carefully finds that they are quite different, both in structure and habits. Locusts have short feelers and are therefore often called short-horned grasshoppers, while the green grasshoppers have long, slender feelers and are known as long-horned grasshoppers. Green grasshoppers live in trees and on the grass, and hop or walk about or spread their wings like sails in alighting on the ground from

a tree. Locusts also hop about on the grass, but in addition to this they sometimes take long flights, going as far as a thousand miles from their first home. Locusts are often yellowish-brown or red in color, but a few are green.

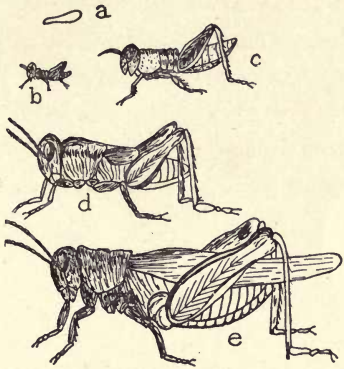


FIG. 219. THE YOUNG GRASSHOPPER CHANGING INTO A FULL GROWN GRASSHOPPER

Some grasshoppers live in caves, however, and so have lost their color. They have also lost their eyes and their wings. Can you tell why? Some grasshoppers are kept as pets. One kind brushes its face with its front legs, just as a cat washes with the front paws. It also cleans its feelers very much as a girl combs her hair; only the grasshopper draws the feelers through its jaws instead of using a comb as a girl does. But grasshoppers do not seem happy in cages and die after two or three years.

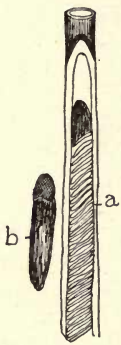


FIG. 220. *a.* The eggs of a cricket. *b.* An egg greatly enlarged.

Grasshoppers eat vegetables and leaves; some eat meat; and others eat both vegetables and meat.

The children of a grasshopper grow from an egg. The eggs form in two little sacs inside the mother-grasshopper's body. They pass out of

the body through two little tubes. At the hinder end of the body is a long, sharp, strong tube. This

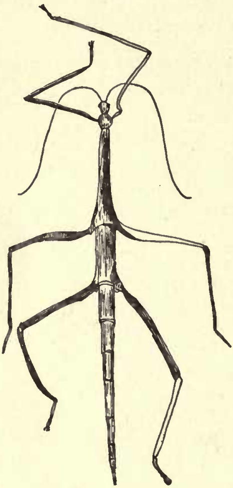


FIG. 221.
A WALKING-STICK

tube is sometimes as long as the body, and is formed by six separate rods or pieces held close together. When the eggs pass out of the mother's body, she digs a hole in the ground with this tube, or makes a hole in some part of a living plant, like the galls of willows or oaks. In this hole, wherever she makes it, she places her eggs. Here they remain from August or September until May or June of the next year.

The little grasshopper grows for a time in the nest; but when cold weather comes, it stops growing. In the spring it hatches and looks somewhat like its parents, only it has no wings. Very soon, however, it slips out of its baby skin, and in a moment it has become much bigger than before, and the beginning of wings can be seen on the sides of its body. After a few minutes it begins to hop about and to eat. Its first

FIG. 222.
A WALKING-LEAF

meal consists of its own cast-off baby skin. As it eats, it grows, and again throws away its skin, until when

this has been done five times the wings are grown and the little grasshopper has become full grown and able to dig a hole in the ground for children of its own.

Crickets, Walking-sticks, and Walking-leaves also belong to the grasshopper family. Most crickets have long, slender feelers like the green grasshoppers, but their wing-covers and legs are different. The tree-cricket lays her eggs in the pith of cane or corn, and in doing this she injures the corn so that it usually dies.

The Walking-sticks and Walking-leaves are very curious looking creatures. Some of them become quite large when

FIG. 223. EGGS OF DIFFERENT WALKING-STICKS

full grown, attaining a foot or more in length. They were given the names they bear because of their resemblance to sticks, twigs, or stems of grass, or to the leaves of trees. Most of them have no wing-covers, but the true wings are often very large. Some walking-sticks never have any wings. Most of these creatures live in warm countries, but a few live quite far north.

The eggs of these animals are as curious as the animals themselves. They resemble the seeds of plants, and the mother lets them drop on the ground from the tree where she sits, without taking any care for their safety. The eggs often lie on the ground for years before they hatch into little walking-sticks.

CHAPTER XVI

THE BUTTERFLY AND ITS CURIOUS CHILDREN

ONE of the first objects usually to be seen in a garden on a summer's day is a brightly colored, fluttering, winged creature called a butterfly. Indeed one sees scarcely more than the bright wings, until the butterfly alights on some flower or shrub. Then a body is plainly to be seen between the wings. There is a well-marked head, a middle portion, and a longer hinder part.

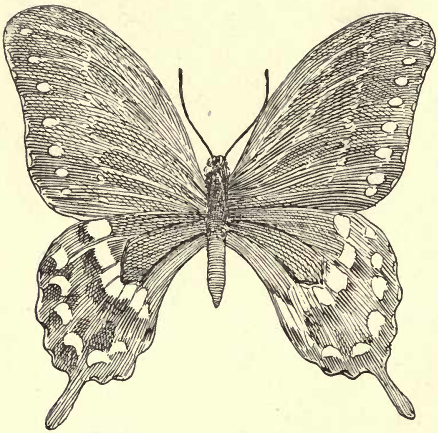


FIG. 224. A BUTTERFLY

At the top of its head the butterfly has two large eyes, each one made up of about thirty thousand six-sided little eyes. Two horny scales at the sides of the mouth serve as jaws. But it has a long, curved lip, and the mouth is coiled up and hidden by the lip until the butterfly wants to eat.

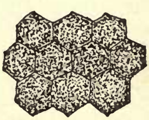


FIG. 225. A PART OF THE EYE OF A BUTTERFLY
Greatly magnified.

Then it uncoils the mouth so that it looks like a long, hollow whip or tapering tube. If you look closely you will see that it is really made up of two tubes, or rather, two half-tubes fastened together along the edges, like two brushes. Is not this a curious mouth? But it serves the butterfly's purpose. For the butterfly eats nectar out of flower-cups, and since these are often deep, it is necessary to have a tube-like mouth to reach it.

Fig. 226. A Butterfly alighting on a Flower

It is a fine thing for the butterfly that its mouth is made up of two parts, for it would be difficult to keep a tube in one piece clean. Since it is in two parts, it can be spread somewhat apart and brushed carefully.

In this tube-like mouth are many small openings and one large opening. The small openings carry air; the large one carries nectar from the flower-cups.

Near the end of the tube are little buds which look like tiny bags; these are probably the butterfly's

tongues, with which the nectar in the flowers is tasted before it is eaten.

At each side of the head are the feelers. These are jointed and club-shaped. One can always tell a butterfly from a moth by looking at the feelers, for a moth has pointed feelers. The feelers are used to touch and to smell with.

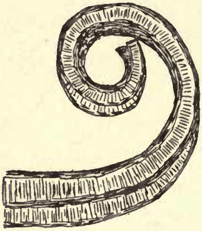


FIG. 227. THE MOUTH OF A BUTTERFLY

Butterflies have six legs. Some butterflies have two pairs of wings and others have only one pair. The wings are covered with feathery scales arranged in rows and overlapping like shingles on the roof of a house. The scales are of many different shapes and are usually brightly colored on the outside of the wing, although the scales on the inside may be dull.

Many butterflies do not live long. The chief object in life of some mother-butterflies is to lay their eggs; they usually die soon afterward. Some butterflies fly away to the south for the winter as the birds do, and others sleep till spring, when they are ready to eat as soon as the first buds open. The father-butterfly must produce sperms so that the eggs may grow, and when he has done this he,

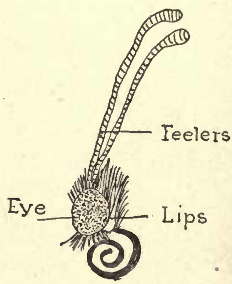


FIG. 228. LIPS, EYE, AND FEELERS OF A BUTTERFLY

too, dies. Some mother-butterflies and some father-butterflies do not live to see their children; and perhaps they would not know them if they did. For their children are all caterpillars at first, and only become butterflies after some time has passed and many changes have taken place.

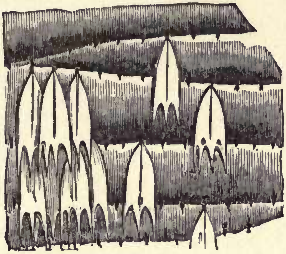


FIG. 229. A PIECE OF A BUTTERFLY'S WING SHOWING SOME SCALES

This is the way it happens: the mother-butterfly lays her eggs upon the leaves of some plant — and curious looking eggs they are, too. They are so small that one must look sharp to see them; but under a magnifying glass they are seen to be of a beautiful color, some pink, some creamy white, and shaped like vases or jewel-boxes, with an opening always at the top.

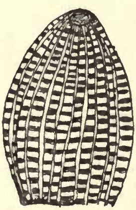


FIG. 230. THE EGG OF ONE KIND OF BUTTERFLY

The eggs are covered with a kind of glue which holds them to the leaves and which protects them from heat and cold and from rough or rainy weather. The eggs laid in the spring soon hatch; those laid in the autumn hatch the next spring. In either case the eggs grow, not into butterflies — but into little worm-like creatures called caterpillars.

As soon as a caterpillar gets out of its eggshell, it begins to eat. First it eats its own eggshell, then it begins to eat the leaves of the plant on which

it is placed. The mother-butterfly seems to know just what kind of plant the caterpillar will like, and always places her eggs on such a plant. The first day the caterpillar eats twice his own weight, and he grows bigger and bigger. In about thirty days he weighs a thousand times more than he did when he was born. You may imagine how much he had to eat to grow so much.

FIG. 231. THE CATERPILLAR COMING OUT OF AN EGG

When many caterpillars live on one plant, it does not take long before all the leaves are eaten, and so the poor plant dies. But the caterpillar goes to another plant of the same kind, and he grows so fast that he has to have a new body-covering five or six times in one summer. Each time the caterpillar changes its covering it becomes more gay-looking, and at last it may be all covered with hairs or have hairs in tufts of bright colors, or it may have red or yellow or white rings around its body. In some caterpillars, black, white, or yellow stripes run lengthwise. The most woolly looking never change into butterflies, but become moths.

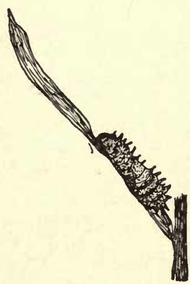


FIG. 232. A YOUNG CATERPILLAR

The body of the caterpillar looks as if it were made of rings. The eyes, which look like two tiny spots, are placed on the first ring. The jaws are strong and horny, and move from side

to side instead of up and down. There are three pairs of legs just behind the head; then there are five pairs of leg-like structures nearer the tail. These are called false legs. The tail itself is sometimes forked. Some caterpillars have two feelers on the head and a stiff bristle on the tail.

Fig. 233. A Cast-off Caterpillar Skin

When the caterpillar eats, it holds the edge of the leaf between its true legs while it holds on to the leaf with the false legs. It eats away one row after another of the leaf-substance until it gets to the middle of the leaf. Then it crawls over to the other side and begins all over again. Soon all the soft green parts of the leaf are gone.

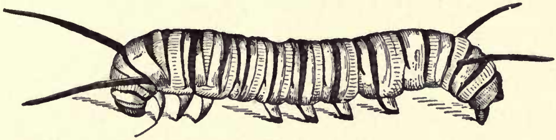


Fig. 234. A Full-grown Caterpillar

You wonder why the caterpillar eats all the time? It must grow and at the same time lay aside food during the summer in order to keep alive during the long winter months when it cannot eat. Besides, from its own body, material must be had for a house to live in during the winter. All must be made from the food it eats.

Of course, the food goes to a stomach where it is

made ready to feed the body. It passes from the stomach to the intestine, and from this to the blood-vessels, which carry it to the muscles and nerves and all other parts of the body. The body needs one kind of food, however, which comes from the air. You already know that this is oxygen. The caterpillar cannot take enough oxygen through the mouth, and it has no nose. Instead, there are little openings like little button-holes on each side of the body, arranged in rows. Each opening leads into a tube which runs inward and unites with a long tube extending from the head to the tail of the caterpillar.

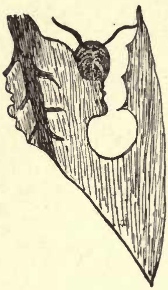


FIG. 235. A CATERPILLAR EATING

From this long tube branches are given off to all parts of the body, so that the air which comes in through the opening can go anywhere and every-

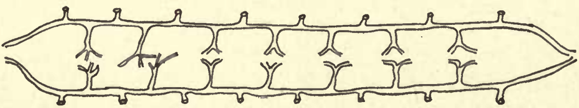


FIG. 236. THE AIR-TUBES OF A CATERPILLAR

where in the body. Indeed, the air goes to the blood instead of the blood going to the air as in our own bodies. The tubes are kept open by a twisted thread which runs all through them. These tubes are called windpipes. When these windpipes contain waste or bad air, the caterpillar moves the

walls of his body closer together and so squeezes it out.

The blood is a colorless, watery fluid and you can see the heart close to the skin on the upper part of the body. The blood flows into the heart through little openings on its sides, and a little slide called a valve in each of these openings prevents the blood from flowing back into the body. As the heart beats the blood is sent from the tail to the head, and from the head it flows into a vessel on the under part of the body.

FIG. 237. THE SPINNERET IN THE UPPER LIP AT THE BASE OF THE TONGUE

The caterpillar has nine or ten little brains. White threads of nervous matter go off from these brains to all parts of the body to regulate its work.

On either side of the food-tube lie two twisted structures which taper to a thread at each end. These structures are filled with a soft, tough glue or gum, which seems to be made in the food-tube, and then is passed into the twisted structures through a fine hair-tube. Another thread leads from these structures to the mouth, and this is called a spinneret or little spinner. When a caterpillar is frightened, it can let itself down from high branches of a tree by means of a thread spun by this spinneret, and so hide in the grass. As soon as the danger

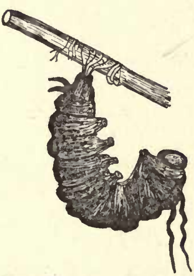


FIG. 238. CATERPILLAR PREPARING TO BECOME A PUPA

is over, it can go back by means of the same thread.

After a time the caterpillar refuses to eat, and looks for some quiet place where he throws off his coat, his jaws, his legs, and even the lining of his stomach. He manages to fasten himself to some object by the little forks in his tail, and begins to spin a covering for himself. Pretty soon he hangs from the twig or branch he has chosen in a little hammock of his own making, like some Indian papoose forgotten by its mother. The caterpillar is no longer a caterpillar, but a *pupa*, which means "mask." Some butterflies make cradles spotted with gold which are sometimes swung from a branch, but which may be laid on some fence-rail or ledge of rock instead. Such a cradle or hammock is called a *chrysalis*.

FIG. 239. A PUPA

If the caterpillar changes into a pupa in the autumn, it sleeps all winter. If it changes in the spring it sleeps about two weeks. If in the summer, when the weather is bright and warm, it sleeps only seven or eight days. If a pupa is kept in a cool place, it may sleep on for two or three years; and if one were brought from out doors in winter into a hothouse, it would come out of its cradle in a few days.

And what do you think has taken place while the caterpillar has been lying so quiet within the pupa-case or chrysalis? If you will watch one open, you will see. First the pupa-case or chrysalis turns dark in color and becomes dry and brittle. Then it splits in several places, and a butterfly crawls out!

At first this butterfly's wings look small. As soon as it begins to breathe, however, the wings become filled with air, and in about an hour the butterfly is ready to fly. It never grows bigger while it lives, but it seems to know just what to do and where to go for the honey it needs and for a mate to help it rear its young.

CHAPTER XVII

THE FRESH-WATER MUSSEL AND ITS FAMILY

WHAT boy or girl has not seen long, narrow furrows along a lake or river shore? These furrows look as if they had been made by somebody dragging a stick through the mud or sand. But if the furrows

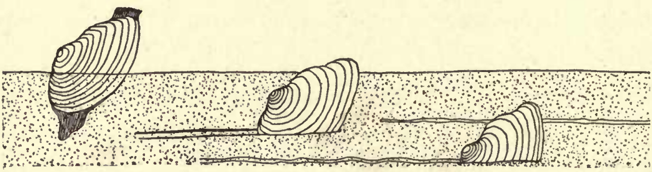


FIG. 240. THE FRESH-WATER MUSSEL MOVING THROUGH THE SAND

are followed, one finds at the end of each a creature covered by two shells, with one part sticking up into the water, and about half of it buried in the mud or sand. This creature is a mussel, although many people call it a clam, mistaking it for its cousin that lives along the seashore.

If one has made the least noise in approaching the mussel, the shells are tightly closed together. But if one waits quietly and patiently for a time, he can see the shells separate a little. The water flows into the shells through an opening about

half an inch long. This opening is fringed with hairs on both sides, and the hairs move backward and forward very quickly, making little currents in the water, which move toward the opening. Near this opening, where the water flows in, is another smaller one from which water is seen to flow from the inside of the mussel shells. If one now pulls the mussel out of the mud and holds it in one's hand, the shells close tight again, so that the openings can no longer be seen. But one can examine the shells better.

FIG. 241. THE FRESH-WATER MUSSEL WITH SHELLS CLOSED

One end is rather pointed and the other, which was buried in the mud, is rather blunt. Near the blunt end is a knob, and about this knob lines run from edge to edge of each shell or valve. Now this knob and these lines have a meaning, just as everything else in Nature has a meaning, when we take the trouble to find out about it. The knob on the mussel's shell shows where the mussel lived when it was little, and each ring or line shows how much the shell grew from year to year, just as the rings in a tree trunk show the age of the tree.

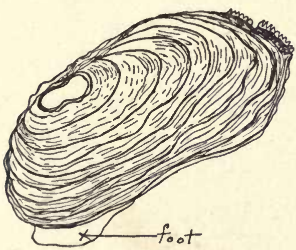


FIG. 242. A FRESH-WATER MUSSEL IN WHICH THE HORNY COVERING ON THE KNOB HAS WORN AWAY
The lines of growth are plainly seen.

Over each shell or valve is a horny covering of a grayish-yellow color; but over the knob this has been worn away and shows us that the shell underneath is made of a sort of chalky substance. Water dissolves or melts lime and chalk, and since this mussel lives in water, he must have a horny covering, which water cannot dissolve, to protect him.

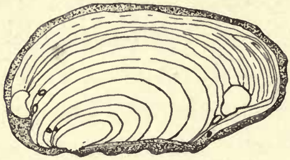


FIG. 243. THE INNER SIDE OF A SHELL SHOWING THE MUSCLE-SCARS

The little scars above the big ones show where the muscles were attached as the mussel grew bigger and bigger.

This is nearly all we can learn about the mussel without opening the shells. The two shells are held together by two strong muscles, one near each end of the shell, and by a tough elastic band, called the hinge. The scars which the muscles leave can be clearly and easily seen inside an old shell. Each shell has two large scars, and above these are little scars where the muscles were attached as they grew. The inner part of the shell is not covered with horny substance, but is smooth and glistening.

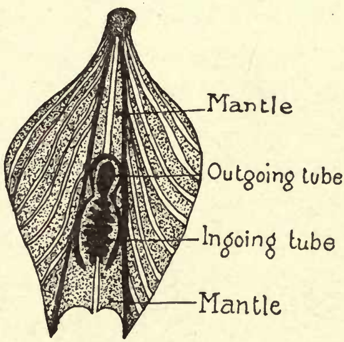


FIG. 244. A MUSSEL HELD SO THAT THE INGOING AND OUTGOING TUBES ARE SEEN TO BE FORMED BY THE MANTLE WHICH IS ATTACHED TO BOTH SHELLS

While the mussel lives in its shell, a soft, thin skin

hangs down close to the inside surface of the shells and covers the mussel like a sort of waterproof coat. A loose, soft coat is sometimes called a mantle; and that is precisely the name given the mussel's soft, inner covering. A number of small muscles in the border of the mantle fix it to the shells. The two openings we saw on the outside pass through the mantle and form two tubes, and the waving, hair-like structures which produce currents in the water are fastened to the edges of these tubes.

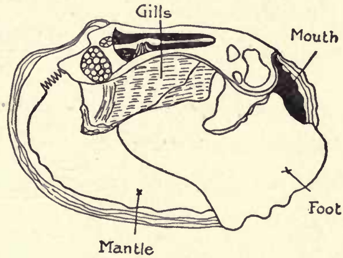


FIG. 245. ONE SHELL REMOVED TO SHOW THE FOOT, THE GILLS, THE MANTLE, AND OTHER PARTS OF THE MUSSEL'S BODY

Resting against the lower part of the mantle is a thick and heavy-looking object, in shape like a plowshare. You will perhaps easily guess that this is the mussel's foot, and that it is by means of this that the furrow is plowed when the mussel moves through the mud or sand. It is by means of this foot, also, that he digs a hole for himself in the earth and lives as happy as can be for days and weeks without moving and with only a tiny bit of his body above the surface. At least everyone thinks the mussel, or "clam" as it is called, is happy, and "happy as a clam" means very happy indeed.

Since the hole for the shell must be bigger than the foot, he fills the foot with water while he digs,

so that it will be bigger. But more wonderful still, in the foot are the mussel's food-tube, liver, kidneys, one of its three brains, and the ears! Think how it would seem to you to have your ears in your feet and go about lifting them up to enable you to hear better! But the mussel's ears are so small that you can hardly see them with the naked eye. They are really little sacs full of a watery substance, and in this substance are little stones which move about when sound-waves reach them. Ask your teacher or your parents to explain how sounds are made. Although the mussel's ears are so very small, they are good servants and let the mussel know at once of the approach of any creature, so that it can close its shells and be quite safe.

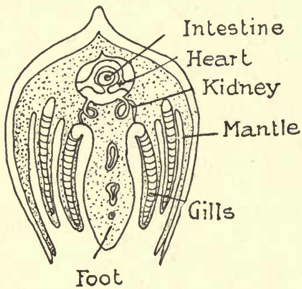


FIG. 246. THE GILLS HANG BETWEEN THE FOLDS OF THE MANTLE AND THE FOOT

Between the foot and the mantle we see two pairs of striped bodies. The outer pair are fastened above to the mantle, the inner pair are fastened to the foot. These are the gills.

You have heard that fishes have no lungs as people have, but breathe by means of gills. Well, mussels have no lungs, and the gills do the same work for them that the lungs do for us. Each gill is a little pocket with holes in it up and down the sides. The water that you saw flow through the opening between the

valves is sent backward to the gills, and then it passes into the little holes and so into the pockets.

The pockets are lined with hundreds and hundreds of little blood-vessels. When the water touches the blood-vessels, the oxygen of the water is pressed into the blood in the vessels, and the poisonous waste matter is forced out of it into the gill-pocket, and so sent out of the body. Water is always running through these gills with oxygen for the blood.

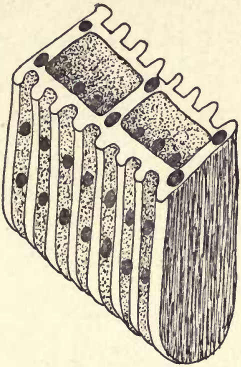


FIG. 247. TWO GILL POCKETS

All the water which enters the tube does not go to the gills. Some of it goes to the mouth. I wonder if you can find its mouth? The mussel has no head; but just in front of the gills are two small flaps, and between these is a wide opening — the mouth. Around the edges of the mouth are little hair-like structures, the *cilia*, which move so that the water flows inward. Little animals like the hydra and the young of the crayfish make a fine meal for the mussel.

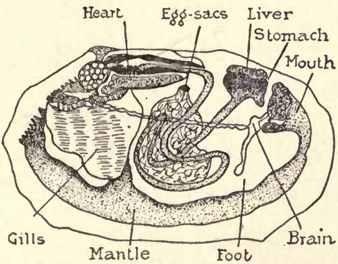


FIG. 248. THE FOOD-TUBE LIES IN FOLDS IN THE FOOT AND PASSES THROUGH THE HEART

The egg and sperm sacs are also in the foot.

Whatever is used for food passes into the stomach, and then into the food-tube or intestine. And the food-tube or intestine runs right through the mussel's heart! To have a big tube filled with food running through the heart seems almost as strange as to have ears in the foot. But the mussel is not a conventional animal according to human thought, and its parts are arranged so that they best suit the mussel's purposes, however strange we may think the arrangement.

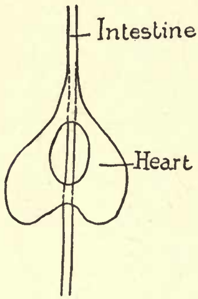


FIG. 249. THE HEART OF A MUSSEL
Showing the food-tube or intestine passing through it.

After the food is digested, the waste parts leave the body through the *anus*. You can see for yourself how the water passes into the mussel and out again if you place a living mussel in a tumbler of fresh water and add a few grains of some coloring matter.

Near the middle of the animal and at the upper border, you may see, through a thin portion of the mantle, something pulsating or beating up and down. This is the mussel's heart. It lies in a chamber filled with watery fluid. It has three chambers — one in the middle and the others attached to it like two wings.

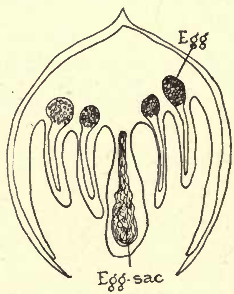


FIG. 250. THE EGG-SAC IS IN THE FOOT, AND THE EGGS PASS INTO THE UPPER GILL-CHAMBERS

The middle room draws itself together and swells out again; then the side rooms draw themselves together and swell out. It is this drawing together and swelling out that is called the beating of the heart, and that is exactly what happens when the heart of a boy or girl beats.

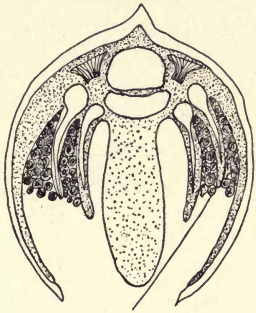

Baby mussels in gill chambers

FIG. 251. THE TINY BABY MUSSELS HELD BY THE GILLS

The parts of the heart draw themselves together in order to send the blood out of their chambers and into the tubes which carry it to all parts of the body. It swells out when blood from the gills is poured into it from the side rooms or chambers. This movement of the blood is necessary to the life of the mussel because it brings oxygen to all the parts of the body. Oxygen is just as necessary for the work done by the cells of which the mussel's body is built, as coal or wood or oil or gasoline is necessary to make an engine move.

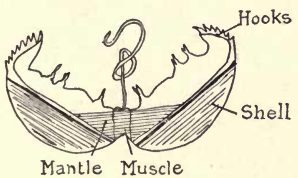


FIG. 252. A BABY MUSSEL AFTER THE SHELL HAS FORMED

But just as an engine needs an engineer to make it move regularly and safely, so the mussel needs a directive power. This is supplied by the nerves. The gills, the heart, the stomach, and all other parts

of the mussel's body are kept regularly at work by these nerves, which look like little white threads. These threads come out from little bunches of nerve-substance which are placed in different parts of the body, and seem to serve the mussel in some such way as our brain and spinal cord serve us. Two of the little brains are found near the muscles which close the shells; two are near the mouth; and two are in the foot. Three of these brains and two nerve cords are seen in Fig. 248. You will agree that the mussel seems to be supplied with all the parts which it needs for its quiet life.

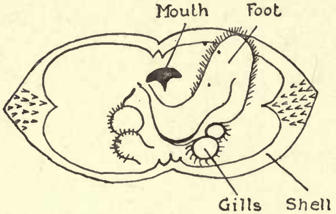


FIG. 253. THE YOUNG MUSSEL WILL SOON BE FULL GROWN

But the mussel, like all other creatures, is expected to provide for its young, and it would seem that five or six children would be enough for one little mother-mussel to care for. But Nature provides many more. Each little mother-mussel carries about with her a hundred times a thousand babies, all carefully wrapped up or clinging to the gill-pockets, and protected by the mother's hard shell. At first they are not mussels at all, but only eggs, and they grow at first in large numbers in the

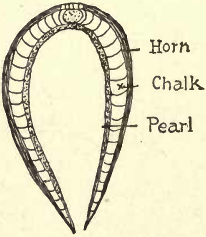


FIG. 254. THE MUSSEL SHELL IS MADE OF CHALK WITH A HORNY COVERING AND A PEARL LINING

mother's foot. When the eggs are full grown, they pass through a tube which carries them out into a chamber which opens to the outside. But instead of passing out of the mother's body they remain for a time in this chamber.

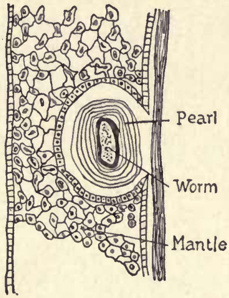


FIG. 255. THE PRECIOUS GEM CALLED A PEARL IS MADE BY THE MANTLE

While the eggs have been growing, small sperm cells in the body of another mussel have formed. These are very much smaller than the eggs, and thousands upon thousands are passed from the father-mussel's body into the water, and so through the inflowing tube into the mother-mussel's body, where they are taken to the chambers where the eggs are kept. One sperm unites with each egg, and then the eggs are carried backward into the water-current again, and are thus caught by the gills. At first each looks like a little globular bottle with a short neck; but soon it grows into a little mussel with a curious three-cornered shell, and at one corner is a little hook. Hanging down from the shell are very many fine threads.

FIG. 256. AN OYSTER

At first the many little ones seem hopelessly

tangled up together inside the gill-pocket. They soon leave their mother, however, through one of the tubes near her back, and swim about by themselves for a time in the water. They would soon tire of this, however; so by means of the little hooks on their three-cornered shells they fasten themselves to some passing fish. Life now becomes full of change for them. Not only are they carried

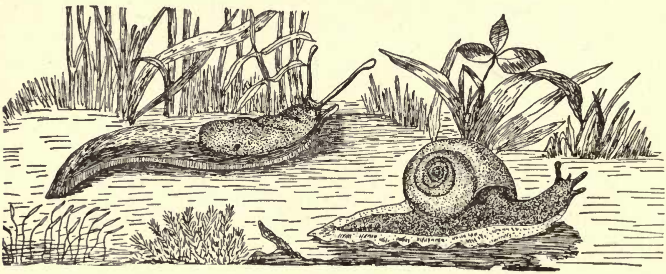


FIG. 257. A SLUG AND A SNAIL

about by the fish from place to place, up the shallows and down into pools, but each mussel changes its form many times while riding about, and at last becomes exactly like its parents. At this time the fish is abandoned, and the mussel goes off to live in the mud or sand, just as the mother and father mussel did before it. There is no need of building a house, for that has been made while the mussel has been sailing; so all that is necessary to do is to carry the house along. Of course you guess that the house is really the shell. And you would like to know just how this shell is made?

You will remember that the mussel has a mantle or soft covering for its body. When we buy a coat or mantle it is likely soon to become worn and unfit for use; — not so the mussel's mantle. This not only does not become worn, but it makes the outer covering for the mussel which we have called the

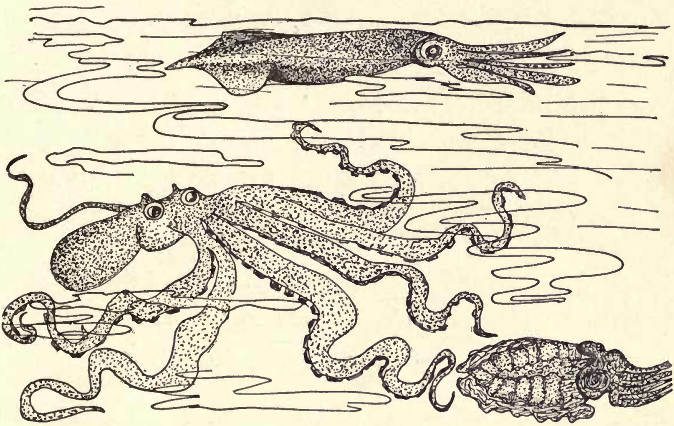


FIG. 258. A SQUID, A CUTTLEFISH, AND AN OCTOPUS

house or shell. There are three parts to the shell: the outer horny part; the middle chalky part; and the inner, colored, shiny part, which is often called mother-of-pearl, and from which buttons and knife-handles are made. The entire mantle works to make the inner, shiny layer; but the two outer layers are made by the edge of the mantle, and if destroyed, cannot be mended or built over again. Sometimes it happens that the young of a worm creeps between the shell and the mantle,

and tries to bore its way into the mantle. Then the mantle surrounds the little worm with a thin fold of its own substance, and covers it over with a fluid which, when it hardens, becomes a pearl. So this wonderful mantle not only builds the house, for the inside of which it forms a soft covering, but it also makes the beautiful pearls which ladies wear as precious ornaments.

Not every mantle makes a pearl. Only a mantle that has been hurt in some way, usually by a small worm or insect, produces a pearl, and it seems to us a wise and wonderful way to cover up a wound.

The oyster and the clam are near relatives of the mussel. The snail, the triton, the scallop, and the slug belong also to its family connections. The cuttlefish, the squid, and the devilfish live in the sea, where they can move quickly about from place to place, or hide in the crevice of a rock. They are able to change their color, too, by means of a fluid something like ink which spreads through cells in their skin. The squid is very beautiful when alive in its home. It is white and almost transparent; but when it becomes frightened it turns a beautiful rose-color. The devilfish, or octopus, is not considered beautiful. It has hundreds of suckers on its long arms, and a large octopus is not thought to be a safe neighbor.

CHAPTER XVIII

FISH FAMILIES

It takes a boy or a girl some time and much practice to learn to swim. Even after learning, it is difficult to keep the head long under water. But fish are born, grow, and spend all their lives in water.

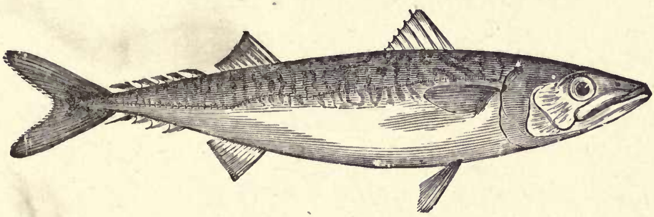


FIG. 259. A MACKEREL

Some live in fresh water and others live in salt water. The ocean was their first home.

Some animals that are not fish live in the water, too, very much as fish do. These are the whale, seal, walrus, and several other animals. Long, very, very long ago these animals used to live on the land; but they left the land and went into the sea, and there they still remain. But as far as we know, fishes have always lived in water, although a few of them have learned to live out of the water and to breathe air for a short time.

The body of a fish is usually spindle-shaped, with a pointed head which cuts the water as the fish swims. The tail acts as a rudder, and also as a sort of paddle to push the fish forward.

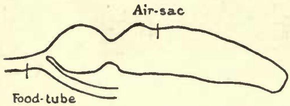


FIG. 260. THE AIR-SAC OF ONE KIND OF FISH OPENS INTO THE FOOD-TUBE

Along the middle line of the body of the fish are structures like the keel of a ship, which help the fish keep a true course in the water. This keel is made of a fold of the skin and has long spines running through it to make it stiff and strong.

At the sides of the body are the fins, also made of folds of skin with spines in them. The fins are the fish's legs and arms, which help it to move upward or downward, forward or backward, or to hold the body suspended in the water when the fish rests.

Do you know why a cork floats on the water and why a pebble sinks? A fish is much heavier than the water and yet it can remain quiet in the water for a long time without sinking, and can raise or lower itself rapidly. Why is this? Because inside its body is a sac filled with air. It is a storehouse of oxygen. The air is lighter than the water, so this air-filled bag helps to keep the fish afloat. Not all fishes have air-sacs, because all do not need them. Fishes

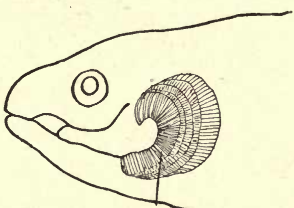


FIG. 261. THE GILLS OF A FISH

that spend much time in the mud or on the sands at the bottom of the sea, like flatfishes and some eels, do not have air-bladders. But the catfish,

FIG. 262. A STURGEON

sturgeon, and codfish have an air-bladder. In some fishes the air-bladder opens into the food-tube; in others it does not do this, but gets its oxygen from the blood-vessels which pass into its walls.

The fish takes its oxygen through its gills. Water is taken in through the mouth and forced out over the gills, which you can see are very red because they are filled with blood. The blood takes

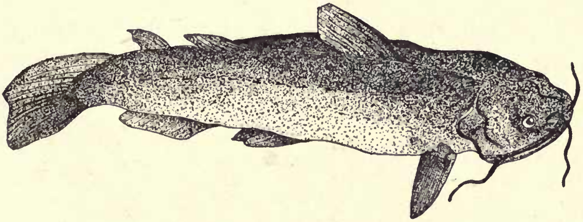


FIG. 263. A CATFISH

up the oxygen from the water and carries it to all parts of the body. The blood also carries waste matter from the body to the gills and there forces it out into the water. So you see the gills do much important work for the fish. Indeed, the fish could

not live without them. In South America and in Africa are regions where little or no rain falls during some months of the year so that rivers and lakes become dry for a time. In such rivers and lakes the fishes have lungs to breathe with during the dry season, and as soon as the rain comes and the rivers and lakes begin to fill, these fishes breathe with gills again.

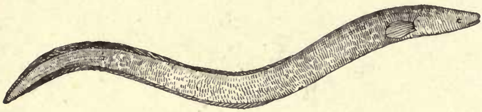


FIG. 264. A COMMON EEL

Some fishes never have any bones in their bodies. Instead of bone, a tough gristle grows as a framework for the body. The sturgeon is one of these. Some sturgeons become very large and weigh as much as five hundred pounds. The body of the sturgeon is covered with large, horny scales, and the beak-like mouth contains many teeth. The sturgeon eats other fishes and kills a great many to satisfy his hunger.

The catfishes have no scales, but have long feelers about the mouth, which help them when they move over the bottom of the rivers where they live. A small kind of catfish is often called "bull-head."

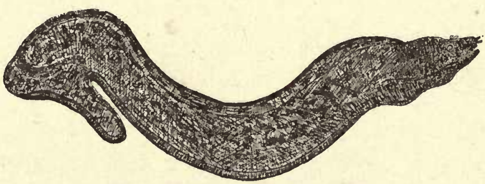


FIG. 265. A ROMAN EEL

One kind of fish looks almost like a snake, so slim

and long it is; but it has no scales, and all snakes do. This slender fish is called an eel. Most eels live in the ocean; but one kind comes into the fresh water of rivers. Some eels are as small as an earth-worm, while others are big and fierce. The big ocean eels eat all kinds of things — it is said they even eat people — or did long ago. They do not live near our shores, but in the warm waters of lands to the south of us.

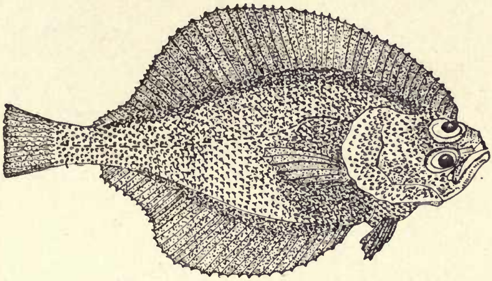


FIG. 266. A FLATFISH

In ocean waters, too, are fishes as flat as a plate, with eyes on the upper part of the body. These fishes are called flounders, perhaps because in moving about they flop and flounder.

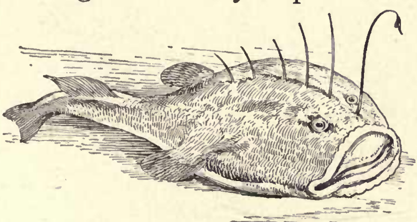


FIG. 267. AN ANGLER

Another fish with a flat body is called an angler, because one of its spines has become changed into a sort of fishpole, with an enlargement like a bait at one end. The angler waves this fishpole up and down until some little fish comes along thinking the bait a worm,

when lo! the angler's big mouth opens and swallows the little fish, and then he at once begins to angle for another.

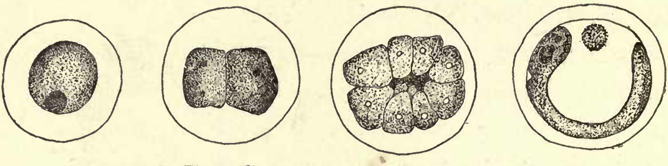


FIG. 268. THE GROWTH OF A BASS FROM AN EGG

One kind of fish has a wide web between the spines of its fin, and whenever it wishes can rise out of the water and fly a short distance in the air.

Fishes usually swallow their food without chewing. Some eat plants; others, flesh. The usual flesh food consists of crayfish, corals, worms, little one-celled animals, and other fishes.

The fish-babies are usually born in the spring and summer. The eggs from which they grow are

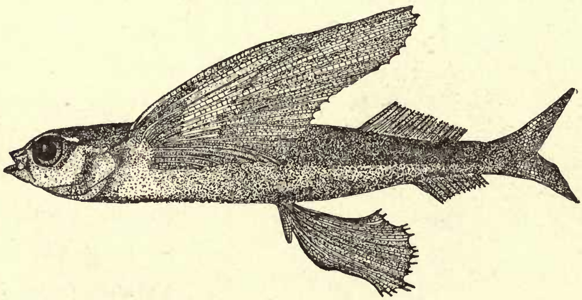


FIG. 269. A FLYING-FISH

formed inside the body of the mother-fish, and as soon as they are laid the father-fish pours sperms over them. Then the eggs begin to divide, to fold,

and to change in form, until a tiny little fish is ready to leave the egg-shell. Some mother-fishes lay the eggs loose in the water; others make nests for them of weeds or stones, and remain about or near the nest until the young are hatched and ready to care for themselves. The father-fish often guards the nest.

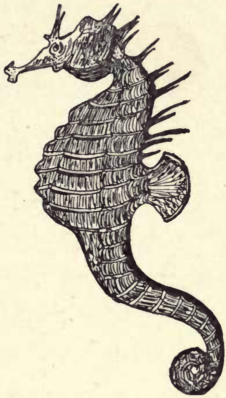


FIG. 270. A SEA-HORSE

Some fishes bury their eggs in shallow sand and the father-fish keeps watch over them. Other fishes carry the eggs in the mouth until they hatch, and still others place them in a pocket on the under side of the body. In yet other kinds of fish, the little ones grow inside the mother's body, and are born alive and able to care for themselves. Some fishes, like the salmon, that live in salt water, go into fresh water to lay their eggs and rear their young; and some fresh water fishes, like the common eel, leave the fresh water to rear their young in the sea.

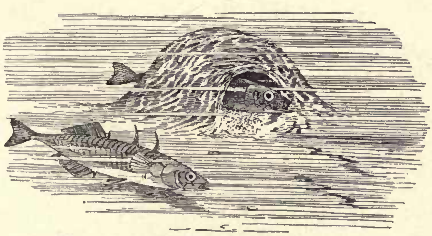


FIG. 271. THE NEST OF A STICKLE-BACK

CHAPTER XIX

THE FROG FAMILY

A FROG lives the life of a fish while it is young; later, legs and lungs grow so that it can live on land. But a frog usually returns to the water as to its home. The land seems to be to most kinds of

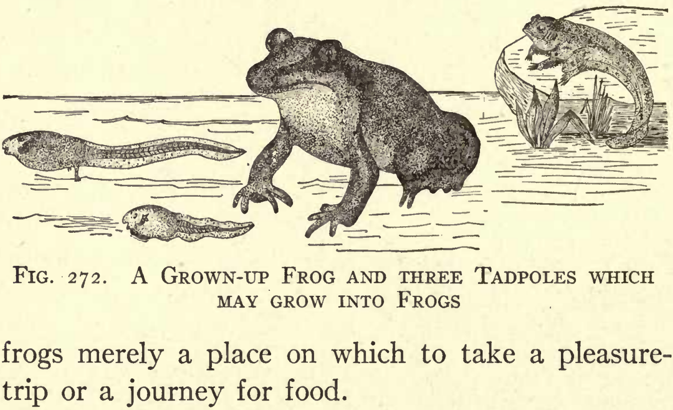


FIG. 272. A GROWN-UP FROG AND THREE TADPOLES WHICH MAY GROW INTO FROGS

frogs merely a place on which to take a pleasure-trip or a journey for food.

When a frog is young it is called a tadpole or polliwog, and it does not resemble a grown-up frog in the least. Sometimes it takes a tadpole two years to change into a frog. The change from tadpole to frog seems wonderful, does it not? But the change of the egg into a tadpole is even more wonderful.

You have seen a frog's egg, have you not, in its covering of transparent jelly? Frog's eggs are not laid singly like bird's eggs, but many hundred cling together in one mass, which is usually fastened to weeds or sticks in a pond or stream. Each egg is round and about as large as gunshot. The jelly that surrounds the egg is in three layers; but all the layers are so transparent that one can distinctly see the egg through them. Each egg is dark brown on top and grayish beneath. The living substance out of which the tadpole will grow is in the dark part of the egg; the yolk, which is to serve as food for the tadpole, is in the lower, light-colored part.

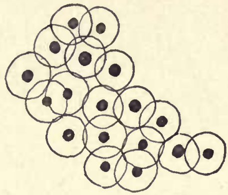


FIG. 273. FROG'S EGGS

As soon as the mother-frog has laid the eggs, the father-frog pours sperm over them, and one sperm unites with each egg. About two hours after this the eggs begin to divide in such a way that one half of the living substance and one half of the yolk become separated from the other half. After a short time each of these first halves divides into two, so that there are now four equal parts in the egg. Next the upper part, which contains most of the

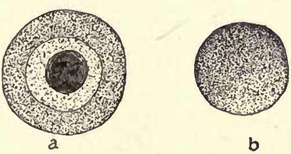


FIG. 274. A FROG'S EGGS
Greatly enlarged

a. Egg in jelly which is shown to be in three layers. *b.* Egg taken out of jelly. It is dark brown on top and grayish-white beneath.

living substance, becomes separated from the part which contains the most yolk, in such a way that the egg now contains eight parts. Each part goes

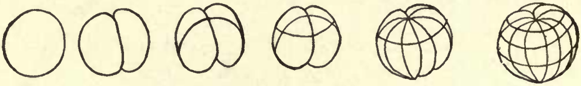


FIG. 275. THE DIVISION OF A FROG'S EGG WHICH ENABLES IT TO CHANGE INTO A FROG

on dividing until there are so many parts that it is difficult to count them.

At this time the form of the egg changes. Instead of remaining round it becomes somewhat oval, and is altogether dark in color except for a small spot where the light yolk can still be seen. The parts of the egg now begin to fold and to separate from one another to form the various organs and parts of the body, such as brain, food-tube, and heart. Three days after the egg began to divide we can tell which part is to become the head and which the tail of the tadpole. On the fourth day two folds have appeared on the top along the entire length of the egg, and these folds are the beginning of the brain and spinal cord. And so one change follows close upon another until soon a little tadpole is ready to leave the jelly where there was only an egg nine days before.

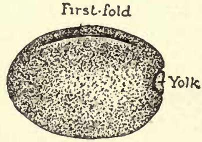


FIG. 276. THE FIRST FOLD IS SEEN IN THE EGG

The little tadpole has two rounded knobs or suckers on the lower side of the head near the mouth,

with which it clings to grasses or water-weeds. A sticky substance like cement is on the surface of the suckers, and it is this which holds the tadpole fast to the weeds or grass. Little finger-like structures come out at the sides of the neck. These are the gills by means of which the tadpole breathes.

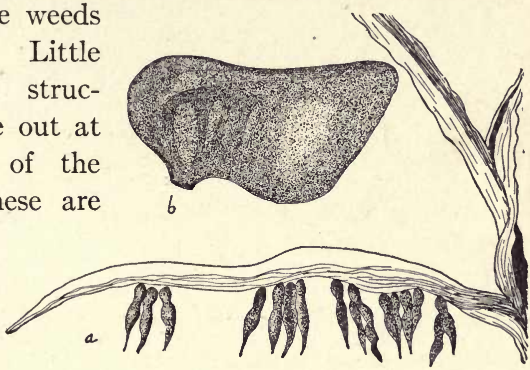


FIG. 277. TADPOLES

a. Tadpoles clinging to the water plant. *b.* A young tadpole greatly enlarged.

The tadpole has no mouth until it is sixteen or seventeen days old. As soon as the mouth is open it begins to eat of the grass or weeds about it. It changes color, too. Instead of being black it is dark brown with gold-colored spots on its skin. It swims, eats and grows, and tries to keep out of the reach of enemies. For the tadpole, though so gentle and inoffensive itself, has many enemies ready to eat him at the first chance.

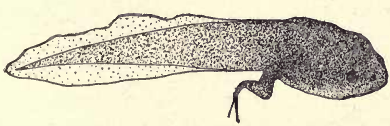


FIG. 278. A TADPOLE IN WHICH THE HIND LEGS HAVE GROWN OUT

Among the weeds and rushes at the water's edge, beetles and worms are found which dart suddenly

upon their prey; or a turtle silently watches from beneath its shield for any living thing; or a fish moves along quietly in search of food and snaps up whatever moving thing comes in its way; or water-birds, wading out into the water to look down with keen, unpitying glance, seize whatever they can. All these creatures think a tadpole a delicious bit for a dinner, and so it is lucky indeed if it saves its life and grows up into a frog.

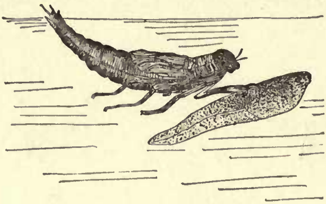


FIG. 279. THE YOUNG OF A DRAGON-FLY CATCHING A TADPOLE

In May or early June the tadpole has grown legs and lungs, and by July or August the tail is gone and the tadpole is no longer a tadpole, but a small frog, two or three inches long.

But if the conditions about it are not favorable for its growth, it may take much longer for the tadpole to change into a frog, and it may remain small a long time. If the pond or pool in which it lives becomes very shallow, so that there is not much water about the tadpole, it grows very slowly, and usually becomes crippled or deformed. In the picture in Fig. 282 are seen

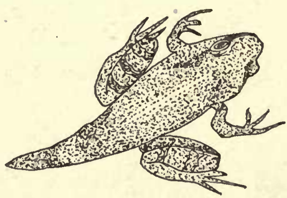


FIG. 280. TWO PAIRS OF LEGS HAVE GROWN AND THE TAIL HAS BECOME SHORTER

two tadpoles which grew from eggs laid on the same day. The tadpole marked (*a*) grew in a large jar of water in which water plants also grew. Tadpole (*b*) grew in a shallow dish in which there was very little water, and in which no green plants lived. After sixteen days both were measured, and the one which had had plenty of fresh water to grow in was twice as large as the one which grew in shallow and less fresh water.

FIG. 281. THE TAIL HAS DISAPPEARED, AND THE TADPOLE HAS BECOME A YOUNG FROG

Not only do tadpoles which have little water about them remain small, but they usually become deformed and remain so for a long time. If such deformed tadpoles are placed in better surroundings with plenty of fresh water about them and green plants to eat, they often recover from their crippled condition and become shaped very much like the tadpoles which grew in plenty of water.

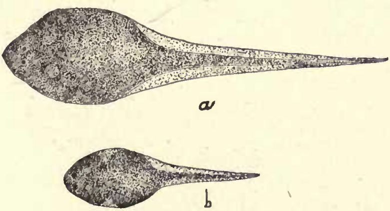


FIG. 282. TWO TADPOLES OF THE SAME AGE

a. Grew under favorable conditions. *b*. Grew under poor or unfavorable conditions.

But it takes them much longer to grow big. The picture in Fig. 283 shows two tadpoles, both nine days old. One is crooked and crippled, and its mouth and gills have not grown so well as the mouth and gills in the well-formed tadpole.

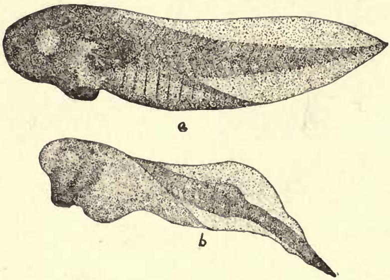


FIG. 283. TWO TADPOLES OF THE SAME AGE
The one marked (*a*) is well grown. The one marked (*b*) is crippled and deformed.

If a frog's egg is injured by cutting or bruising, it may still grow into a tadpole. But such a tadpole is also usually deformed or crippled. Only the eggs which grow in the surroundings that are best for them, with plenty of water, and air, seem to change into well-formed and strong frogs.

Sometimes the young frog leaves the shelter of the sedgy water and journeys inland to the meadow in search of grasshoppers, crickets, or spiders. A frog can eat five or six grasshoppers at a meal, and it does not seem to care that there is not room for the legs inside its body, but will often leave these sticking out of its mouth for a time.

FIG. 284. A FROG DINING ON GRASSHOPPERS

It is very interesting to see a frog catch a fly or a grasshopper. All it does is to sit quietly near the roots of a tuft of grass and then when a fly or a grasshopper comes along, out darts the tongue to snap it up. For it can throw the tongue outside of the body and pull it back again in the most convenient way. The tongue is slender in front and forked behind. It is fastened to the floor of the mouth in front, and covered with a sticky substance.

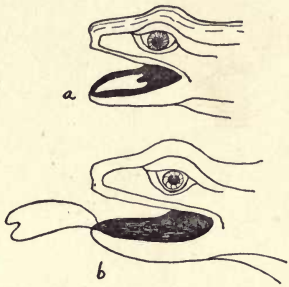


FIG. 285. TONGUE OF A FROG
a. The tongue at rest in the mouth. *b.* The tongue thrown out to catch an insect.

When anything moves in front of the frog, out flies the forked tongue, and it is at once drawn back with the fly or grasshopper wrapped up in it. The frog does not have to work hard to catch things either. There is a little sac under the tongue filled with a fluid called lymph. When a little muscle underneath this sac shortens, the fluid goes into the tongue and pushes it out just like a Jack-in-the-box.

FIG. 286. A FROG'S SKIN WHICH HAS BEEN SHED

The frog has many teeth at the edge of the upper jaw, and also in the roof of the mouth. The teeth are not used to chew with, but to hold on to its food, and as soon as any are worn out new ones grow.

While a frog eats a great variety of things, it never drinks. The water it needs is taken into the body through the skin. For that reason a frog which has been kept in a dry place for some time becomes shriveled and thin, and at last it dies if it is not replaced in water.

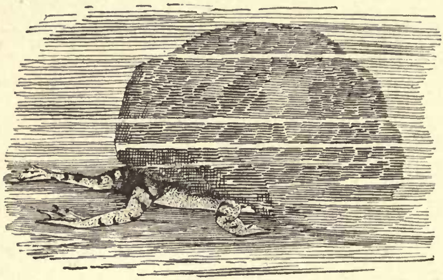


FIG. 287. A FROG UNDER A ROCK WHEN THE WATER ABOUT IT HAS BECOME VERY COLD

The frog sheds its skin three or four times a year, and it comes off in patches in some kinds of frogs, entire in others. Frogs often eat the skin that has been shed.

Frogs feel cold to the touch of a human being, so that they are called cold-blooded. This is because the oxygen within their bodies is not used up so rapidly as in birds and higher animals. The colder the water the colder the frog becomes, until in winter its body is cold and stiff and it cannot move. When very cold weather comes, the frog moves down to the bot-

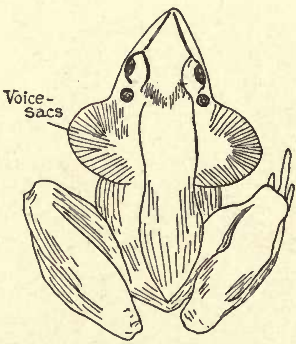


FIG. 288. THE VOICE-SACS FILLED WITH AIR

tom of the pond and burrows in the mud or crawls under a rock or a stick. Here it lies all winter without breathing or eating. A frog may even be frozen for a short time, and when it thaws out again it goes on living as before.

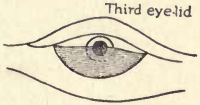


FIG. 289. THE THIRD EYELID

As soon as the frog comes out of its burrow in the spring, it begins to croak and to sing. The song or croak is made in a little box near the top of the wind-pipe. Little cords are stretched across the top of this, and whenever the frog sends out a deep breath and opens its mouth a sound is made. The father-frog has a bigger voice-box than the mother-frog, so it is the father-frog that croaks and sings the loudest. Besides the voice-box, some frogs have two sacs, one on each side of the voice-box, which can be filled with air and help to make the voice louder.

FIG. 290. A TREE-FROG

If you pass something in front of the frog's eye, you will see that a thin white curtain rises from under the lower lid and entirely covers the eye. This is a third eyelid, which has almost disappeared from the eyes of the higher animals. The frog has three, and when it closes

its eye it first draws the eyeball into the socket, then it pulls the thin white eyelid up over it; then the upper and lower lids draw close together, and the eye is closed. The pupil of the frog's eye is large and narrow; the eye itself is round.


FIG. 291. A SPRING PEEPER

Frogs hear very well. When one frog croaks, another usually answers. Splashes and croaks are the sounds most noticed. When the splash of one frog is heard, all the other frogs listen attentively.

There are many kinds of frogs. Some kinds live in the woods and are called wood-frogs. Others climb on trees and are called tree-frogs. Very small frogs which cannot climb trees, but live on the ground, or jump from lily pad to lily pad in search of food, and sing meanwhile like crickets, are called cricket-frogs. Then there are bull-frogs, the largest frogs of all, which do not leave the water to search for food, so they are not usually seen in meadows or marshes but in rivers or ponds. The spring peeper begins to sing early in March, and "Pe-ep, pe-ep, pe-ep, pe-ep" is heard from marsh and pond and weedy ditch.

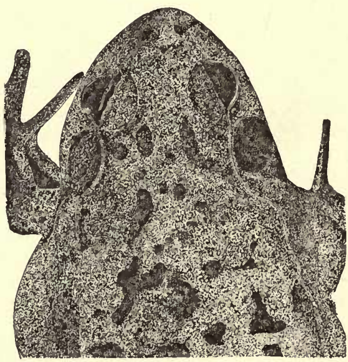


FIG. 292. A BULL-FROG

Frogs usually differ in appearance and color, according to the region in which they live. Southern frogs are sometimes more brightly colored than frogs which live in the north. Frogs which live in the eastern part of America usually differ somewhat in appearance from those living in the mountains of the west or along the western seashore. But whatever their size, appearance, or habit, most kinds of frogs grow from eggs which are laid in water, and here they change into tadpoles and then into frogs.

CHAPTER XX

THE LIFE OF A BIRD

Everybody knows at least one bird, for birds live everywhere, on the ground, in the trees, or on the water. Some birds spend most of their lives in the air. No place seems too hot or too cold for the home of some bird, and travellers find them in the icy north, as well as in the torrid south. Even in the crowded city the pigeon coos cheerily and the sparrow flutters on the ground.

Fig. 293.
Cardinal Grosbeak

Everybody knows, too, that birds can fly; but many creatures that are not birds can fly, also. Birds are the only creatures, however, that have feathers; so if you are told of a flying creature without feathers you may know that it is not a bird. Feathers are a warm covering. They also help the bird to fly. They are broad, so that they can act like paddles in

the air, yet light, so that they do not drag the bird to the earth with their weight. Feathers grow out from the skin of the bird, just as scales do from the skin of the fish or lizard. Indeed, a feather is merely a frayed-out scale.

Besides having feathers to help in flight, the bird has little sacs like balloons inside the body. These sacs are filled with air which flows into them from the bird's lungs, and which passes from the sacs into the bones and other parts of the body, making these light. Every time the bird breathes, the sacs as well as the lungs and bones are filled with air. When the ribs and other parts of the body-wall press upon the sacs the air passes out, only to be replaced by fresh air. This is the reason birds are lighter than other animals and can sail along in the air for hundreds of miles.

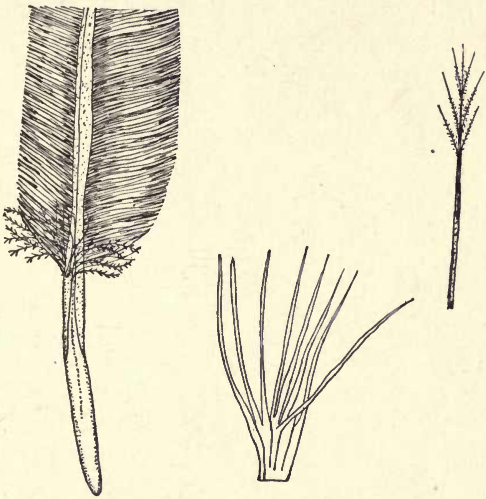


FIG. 294. THREE KINDS OF FEATHERS

Many people think that birds sing more sweetly and beautifully than other creatures, even more

beautifully than human beings. Birds can sing sweetly because their voice-box is made differently from that of other animals. Instead of being placed near the throat as in human beings, it is down in the breast in birds, at the place where the windpipe forks to go into the lungs. The wall of the bird's voice-box is thin, and instead of having cords stretched across it, there is a thin flap, called a valve, which works like the reed in an organ-pipe. That is the reason birds can make such fine music.

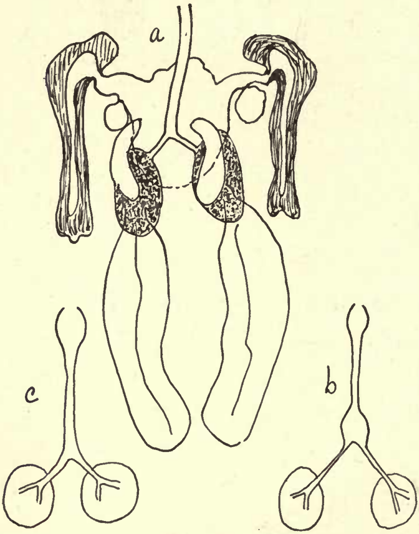


FIG. 295.
a. The air-sacs and lungs of a bird. One of the sacs is seen to open into the big bones of the wing. *b.* The voice-box of the bird is near the lungs. *c.* The voice-box of a human being is in the throat.

Some birds never sing; but all give some sort of a call or whistle. What country boy or girl does not know the call of the loon from the distant lake or the whistle of the quail in the wheat fields? And the whippoorwill! How glad everybody is to hear him in the bright moonlight evenings when there are deep shadows in the woods and nothing else

is to be heard except the chirping of the crickets in the grass!

But while most people know the call, song, or appearance of some birds, few know about the life of a bird, and how it grows before it is ready to leave its nest.

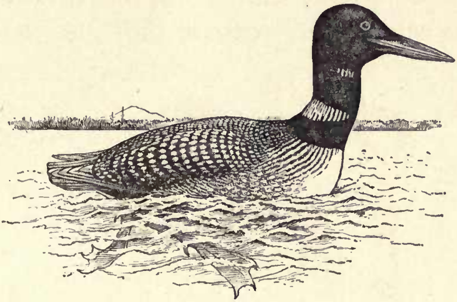


FIG. 296. A LOON

Most birds make a nest as a home for their little ones. They not only make a nest, but many birds travel thousands of miles every spring in order to be able to make the nest near the place where their own lives began. For birds do not forget their childhood home, but return to it year after year. Many birds are obliged to go away for the winter, but as early as possible in the spring they come back and stay until the weather warns them to leave again.

FIG. 297. A WHIPPOORWILL

Some birds do not go very far away. The robin, the bluebird, the redwinged blackbird, and the purple grackle go south only as far as Georgia or Florida. But the bobolink journeys down into South America where the flowers are big and bright in our winter, and where there is an ample supply of

FIG. 298. THE NEST AND YOUNG OF A SPARROW

seeds. Some birds, like the eagle, make their homes in high mountains, and others look for rocky islands in the sea. All the bird-children return to build their homes in turn and care for little bird-families, just as their fathers and mothers and grandparents did before them.

Birds make careful preparations for going, too. On a journey they never carry a trunk or suit-case

as we do. But they change their dress completely, and every feather is polished and clean. In the spring, before they go back to their old homes, they put on gay apparel. Some birds wear a head-dress of yellow, red, or gold. Others wear a crest, and stripes on the wings and tail. Still others wear streamers fastened to the shoulders or tail,

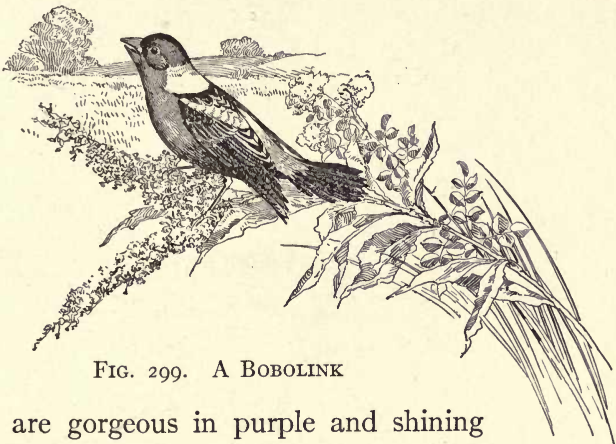


FIG. 299. A BOBOLINK

and are gorgeous in purple and shining plumes. Some people say that a bird makes such great ado about his dress in the spring because he expects to get married as soon as he gets home. And it certainly seems to be true; for no sooner is the old home reached than he begins to look about for a mate. As soon as the lady of the bird's choice has consented to marry, the two set about preparing a home.

The robins make their home of grasses and straw and hairs, and smooth it nicely inside. The orioles weave their nests of bits of moss and leaves and

grass and thin birchbark, and hang it from the limb of a tree like a tiny hammock. The bluebird and the flicker prefer a hollow tree or stump, and so they escape the work of building. Barn swallows make their nests of mud and place them under the eaves of a barn, or, if the doors are kept open, on the rafters in a hayloft. Bank swallows dig tunnels and chambers in the earth. The crow is satisfied with a few sticks and twigs laid across the branches of a tree.

FIG. 300. AN EAGLE

Humming-birds have such tiny nests, built of moss and spider webs and lined with down. The cowbird and the European cuckoo do not build at all, but steal into some other bird's nest to lay their eggs, careless of what becomes of their little ones. Gulls, terns and ostriches make no nests. A little hollow in the sand is all the home they provide.

In great contrast to these shallow hollows are the nests of some South American and African birds, that weave nests of grasses and straw about the shape of a Christmas stocking and as long as your arm. The nest does not open at the top, but near

the middle of one side. The walls of the nest are thick enough to protect the little ones from sunshine and rain, and great fun it must be for them to swing back and forth in the wind on a summer's day, with never a fall to be feared.

All birds do not agree as to what sort of home is the prettiest and the best; but every kind of bird makes a different kind. Sometimes the lady-bird chooses the place where the home is to be built; or the husband finds a place that suits him and then coaxes his wife to join him. The mother-bird may do all the work of building herself; or the father-bird may help her. When the home is finished, it belongs to both.

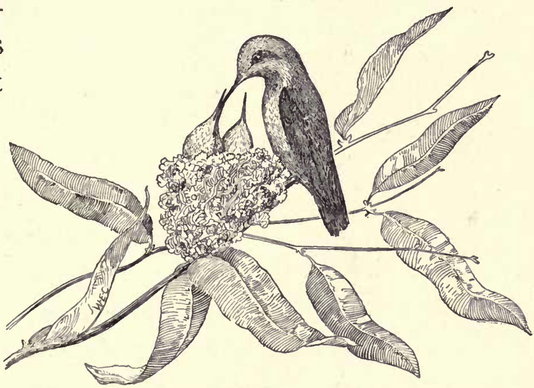


FIG. 301. THE NEST OF A HUMMING-BIRD

Why do some birds prepare such good homes for their young, and other birds do very little in the way of home-making? Why do some birds build a bird-city, with all the nests close together, and other birds go off by themselves, and never visit others of their kind until the little ones are able to take care of themselves?

How do the young birds learn to build a home? Does anybody teach them? One can ask many questions about birds, and all can be answered by watching carefully, to see just what the birds do.

FIG. 302. THE NEST OF AN AFRICAN BIRD

Some thoughtless boys kill birds and even steal birds' eggs. They would not do this if they knew how useful the birds are in helping farmers and gardeners to keep harmful insects out of the fields and gardens. Birds also eat decaying flesh and vegetables, and so clean the earth for the use of human beings. Do you think a boy would rob a bird's nest if he had ever seen how long and patiently and busily the birds work in making it, and how happy they are when it is quite finished? For as soon as it is finished the mother-bird places in it some wonderful eggs—very different from the frog's or fish's eggs—for they are enclosed in a brittle shell which is often prettily colored and marked.

FIG. 303. NEST AND EGGS OF THE KILLDEER

Birds' eggs are much bigger than frogs' eggs, too;

because inside the shell a little bird is to grow. And this little bird must be big enough to eat when it gets out of the shell, for it cannot live outside of the shell without eating, as the tadpole does when it leaves the jelly surrounding it. And how do you think the bird's egg gets its shell? In much the same way that the frog's egg gets its covering of jelly.

FIG. 304. A BIRD OF PARADISE

Inside the mother-bird's body, and fastened to the upper part of the body-wall, is a cluster of cells which gradually grow bigger and bigger. In the spring, after the mother-bird has chosen her mate, some of these eggs drop off, one by one, and are taken up by a wide-mouthed tube. Each egg consists of a small bit of living substance and a large amount of food material. There is yet no white and no shell about the egg. For the egg was formed so

FIG. 305. THE NEST OF THE BALTIMORE ORIOLE

that another little bird could grow, and the living substance in the egg cannot grow until another kind of living substance has been added to it, just as we learned when we studied the life of the fish and the frog and the other animals.

The living substance necessary for the growth of a bird is found in the sperm cell, which grows in the father-bird's body. Before the egg becomes covered with the white or the shell, the father-bird places the sperm in the tube where the eggs are, and one sperm unites with each egg. Then a structure in the wall of the tube makes the white with which to cover the egg, and another structure makes the shell. The white is for food for the bird which will grow; the shell protects both food and living substance.

Fig. 306. A Flicker in its Home

There are little openings in the shell, so small that they cannot be seen with the naked eye, but they are big enough for air to pass through. Some birds lay two, others four or more eggs at a time. But after the eggs are laid they must be kept warm, and

this the mother-bird usually does by sitting on the eggs so that her breast covers them. While she sits on the eggs, the father-bird gets food for her — either worms and flies, or berries and seeds, whichever she likes best. Sometimes the mother-bird leaves the nest for a little exercise, and then the father-bird takes her place on the nest.

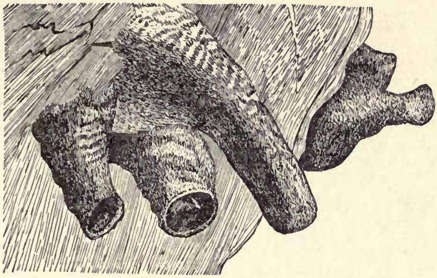


FIG. 307. SOME HOUSES IN A BIRD-CITY

And so the days go by, and all the time wonderful changes are taking place inside the egg. At first there was only a little bit of living substance in the form of a simple cell, lying on top of the yolk. But very soon after the egg is laid, many cells form from this one cell, and all the cells arrange themselves in layers. The layers become folded in such a way that a long, narrow creature is formed, which lies on top of the yolk and looks more like a fish than a bird.

FIG. 308. A GROUP OF BIRDS' EGGS OF VARYING SIZE AND SHAPE

But as the days pass, the fish-like creature changes more and more into the form of a bird. The yolk

and the white disappear, because the little bird-creature must have food. In two or three weeks the food is all gone, and the little creature is a real bird which cannot remain inside the shell longer if it is to continue to live. So it pecks at the shell with its bill, the shell cracks, and out steps the bird!

FIG. 309. THE EGG-SAC OF A BIRD

And the tube through which the eggs pass out of the body and in which each egg is surrounded by the white and by the shell.

How happy the mother and father birds are when they see it! They flutter their wings and utter sharp little calls, and then the father-bird goes off to get food for the hungry little one. For once outside the shell there is no more yolk to eat, and the little thing is growing bigger every minute and needs food to grow on. The mother-bird settles down again to keep the other eggs warm and also to warm her new baby, whose feathers are as yet mere down and scarcely cover all of the body.

In a few days all the eggs are hatched, and then both the mother and father birds are obliged to hunt for food for their growing brood. And such a busy time they have! More than a hundred times each day they fly back and forth,

back and forth again, with worms, seeds, or berries for their hungry little ones.

Some kinds of birds not only find the food, but change it into a pulp in their own bodies, then pump it down the throat of the little one. Each little one stretches his neck and opens his mouth to reach the food brought, and those that are not fed each time cry and cry. If either mother or father bird is killed by some cruel hunter or by some animal, the work of feeding all the birds falls upon the parent that is left alive. And you can easily see how hard that must be!

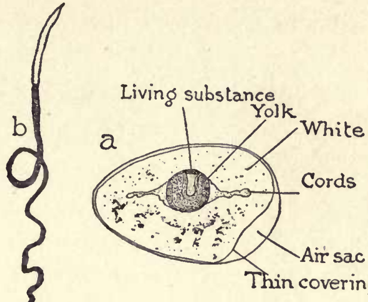


FIG. 310. EGG AND SPERM CELL

a. The egg of a bird drawn to show the thin covering about the white; the white of the egg; the dark, and the lighter part of the yolk; the living substance lying on top of the yolk; and the cords of white which hold the yolk in position. *b.* The sperm cell of a bird.

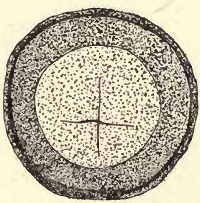


FIG. 311. THE LIVING SUBSTANCE ON TOP OF THE YOLK WHICH HAS DIVIDED INTO FOUR CELLS

After a time the down over the little birds' bodies is replaced by feathers, the wings grow strong, and the legs sturdy. Now it is necessary for them to leave the nest in order that they may learn how to care for themselves. The mother and father bird love their little ones very much, but they understand that a

bird cannot be happy unless he is able to take care of himself. To learn to do this he must leave the nest and learn to fly and to hunt for food.

So the mother and father birds teach the little ones to fly. If the little ones are afraid to go they are pushed out of the nest. At first they fly only a short distance. Sometimes they fall to the ground, and flutter about before they have courage to try their wings. But at last off they go into the sunshine and over the fields and woods, their eyes gleaming with the joy of power and independence.

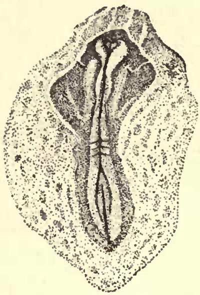


FIG. 312. THE LIVING SUBSTANCE IN THE EGG HAS CHANGED INTO A FISH-LIKE CREATURE

After this the parent-birds do not feed them, and some seldom go back to the old home, while others remain near the home-nest for many months. In the autumn, when the cold weather comes, these little birds, now grown big and strong, gather with others of their kind in preparation for the journey southward; and with the return of spring, these birds that we have watched in their parents' nest come back to build nests for themselves

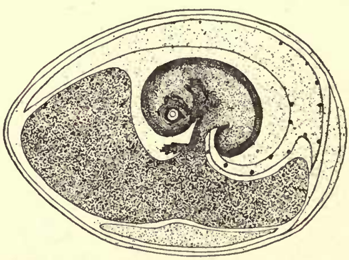


FIG. 313. THE LITTLE BIRD AND ITS COVERINGS AND FOOD-SUBSTANCES WITHIN THE SHELL

and rear young, just as their parents did before them.

And so bird-life goes on, very much like the life of human beings. Only, of course, few human beings go south for the winter. Human beings have learned to bring the south to their own homes instead, so that the young can be cared for much longer than birds care for their young.

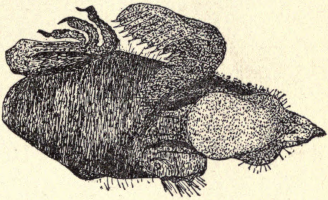
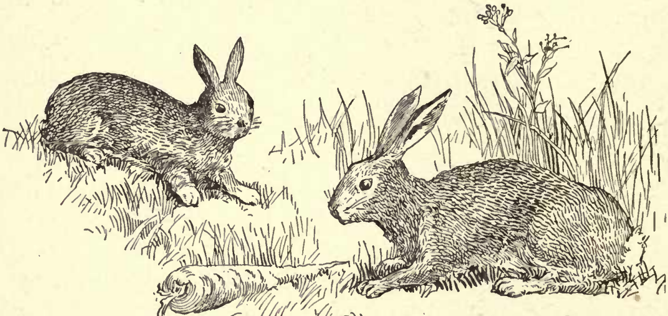


FIG. 314. A NEWLY HATCHED BIRD

CHAPTER XXI

THE RABBIT AND HIS CHILDREN

EVERYBODY knows the story of the race between the tortoise and the hare. The rabbit is the hare's close kin — a sort of cousin. The hare is big, with long ears and long legs. The rabbit is small, with



a b

FIG. 315.
a. A rabbit. *b.* A hare.

shorter legs and shorter ears. The hare changes its color with the season, wearing a brownish coat in summer, a white coat in winter. The rabbit wears the same kind of dress all the time; and this may be brown or gray, or even white. When the rabbit's coat is white, its eyes are always pink. What color are the eyes of a brown or a gray rabbit?

The hare can run miles and miles without getting

tired; but the rabbit gets tired very soon, although it can run very fast for a short distance. The hare makes a nest for a home; the rabbit digs a burrow, sometimes beneath a large tree, so that the roots help to protect his home. Sometimes he finds a deep crevice in a rock, or a hole in a tree-stump that suits him just as well. What the rabbit wants most of all is for no one to see him.

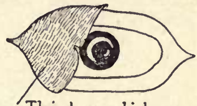


FIG. 316. THE EYE OF A RABBIT SHOWING A THIRD EYELID

His flesh is good to eat, and the fox and the dog and many other animals know this. So, since his coat is grayish-brown, he sits close to the ground if dogs or foxes are about. If they get near him, he dashes quickly past, only to creep into a burrow at the nearest possible point.

He never sleeps in the daytime, because if he

FIG. 317. A RABBIT'S BURROW

slept he might not hear or see an enemy coming, and be ready to dash past and hide.

The rabbit likes best to live in dry fields or woods, and eats almost any vegetable food — cabbage,

turnips, celery, carrots, dandelions, and chickweed. In winter, when this food is scarce, he eats the green bark of trees and shrubs, and many an apple and cherry tree in the orchard is killed in this way. For, as you know, the tree cannot live without its green bark.

But the rabbit differs much more from birds and frogs and fish than he does from the hare. In the

FIG. 318. RABBITS AT HOME

first place one sees at once that the rabbit is covered with hair instead of feathers or scales. Birds, frogs, and fish never have true hairs on their bodies; but many animals besides the rabbit are covered with hair. Of course you think at once of all the animals you know that are hairy: the cow and horse, the pig and goat, the squirrel and mouse, the cat and dog, the bat and the opossum, the monkey and man. All these and many others at some time of their lives have hair over their bodies, and in

this respect they are unlike other animals and like the rabbit. They differ from other animals in another important way, besides. This is in the way in which they feed and care for their young.

You will remember that young fish eat grass or weeds or worms and crabs; that tadpoles eat weeds; that little birds eat worms or berries or seeds. But the young of hairy animals drink milk, and do not eat at all for some time after they are born. And where do they get the milk? From their mother, of course, and the milk is made in her own body, for this very purpose. Cow's milk is really made for the little calves, only we find it good and so we use it without saying "if you please," to either cow or calf. The milk forms in little sacs, called glands, outside the muscles and inside the skin in the cow's body, and from these glands it is poured into tubes which lead out from the teats of her udder.

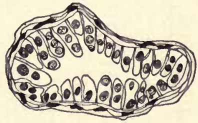


Fig. 319. A Part of a Milk-gland

It is the cells of which the gland is built which produce the milk.

In the same way milk is made in the goat's body for her kids; the colt is fed from the milk of its mother; the kitten, the dog, and the little rabbit are all fed the same way at first, upon their mother's milk. The sacs in which the milk forms are called *mammae*, and so all the animals that are fed with the milk of mammae are called mammals. Since the mother-rabbit has mammae and feeds her young with milk, the rabbit is also a mammal.

The life of a rabbit differs from that of frogs and birds and fish in another way. As you will remember, fish and frogs and birds grow from eggs outside the mother's body. The rabbit grows from an egg inside the mother's body. This is because the rabbit-baby needs much more care and protection than a tadpole or a bird at the time when it first begins to grow. And so, instead of letting the eggs pass out of her body into the water, as frogs do, or into a nest, as birds do, the mother-rabbit keeps them right inside her own body until each egg has grown into a little rabbit.

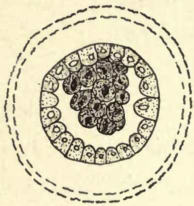


FIG. 320. A RABBIT'S EGG AFTER IT HAS DIVIDED MANY TIMES

Each rabbit's egg is a cell, just like the bird's egg, only it has not so much yolk. This cell leaves the place where it grew and is taken into a wide tube, through which it is carried into a still wider tube, where it stops until it meets a sperm cell from the father-rabbit's body. It then unites with this sperm cell and clings close to the wall of the big tube where it lies. Within a short time the single cell has divided into many cells, just as the frog's egg does. Then a

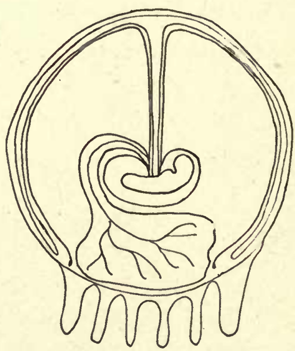


FIG. 321. THE TINY BABY RABBIT IN THE BIG TUBE OF ITS MOTHER'S BODY

great many coverings grow around it, and blood-vessels from the mother-rabbit's body grow through these coverings in such a way that food is brought to the little rabbit from the mother-rabbit's body, which is the reason the egg does not need much yolk to begin with.

The little rabbit grows within its mother's body for about a month, and usually four or five sisters and brothers grow at the same time in the same chamber, and when they are big enough, they are all born at the same time.

The little rabbits are blind for some days after birth, and have very little hair on their bodies to keep them warm. So the mother and father rabbits prepare homes for them in burrows under the ground, where they can be safe from dogs or foxes that might take them and eat them up.

CHAPTER XXII

HOW ANIMALS BECOME SICK

Animals as well as plants may become diseased and often from similar causes. Those animals whose bodies are weakened in some way most readily become diseased. The bodies of some animals may be weak from the time they were born because their parents were not strong or not well; or, if animals are kept in places where they cannot breathe pure air, they become weakened and sometimes even die. If animals are not able to get pure water or good, clean, nourishing food to eat, they also become weakened and are liable to become diseased.

Diseases in animals are often caused by the same kinds of parasites that cause diseases in plants. Bacteria, rusts, smuts, insects, and worms cause most of the sickness among animals. These get into the body through the nose or mouth with the air breathed or with the food or water taken. Parasites may also get into the bodies of animals through cuts or bruises.

We do not know so much about sickness in wild animals as in our tame or domestic animals; but both wild and tame animals seem liable to the same kinds of disease. Since tame animals give us much

of the food we eat, and since we may take disease from them, it is very important to keep them in good health, and to know how to cure them when they become sick.

About fifty years ago so many sheep became sick and died in France that the French people had very little mutton to eat, and they feared that soon they would have none at all. So the French government asked a good and learned man to study carefully the sick sheep and try to discover what caused their illness. This man was Louis Pasteur. He went into the country where the sheep were sick and dying and found that their sickness was caused by small, rod-shaped bacteria, which got into the sheep's bodies through the nose or mouth, or even through the skin, and then made their way in the blood to all parts of the body. The spleen, especially, became swollen, and so the disease was called splenic fever.

FIG. 322. A CUT IN THE LEG OF A HORSE PERMITS BACTERIA TO GET INTO THE BODY

After thinking long and working hard to find a cure for this disease, Louis Pasteur discovered that if the animals were vaccinated in a certain way they would not become sick nor die. So the French people's sheep were saved, and today, in most countries of the world, if the bacteria of splenic fever threaten the health of sheep, they can be saved by Pasteur's

way of vaccinating them. Not only sheep, but goats, pigs, horses, cattle, and chickens may become sick with splenic fever, and it sometimes happens that human beings also take the disease.

Louis Pasteur did many things to save animals and man from disease besides discovering a cure for splenic fever. Among these things we are especially grateful to him for finding a way to prevent or to cure rabies or hydrophobia.

FIG. 323. LOUIS PASTEUR

Dogs, cats, wolves, and some other animals are liable to become attacked by the disease called rabies. It is not yet known whether this disease is caused by a single-celled animal or by bacteria. But the parasites get into the spinal cord or brain and cause so great distress that a dog attacked by them is usually said to be mad. Human beings may be given this disease through the bite of a mad dog. But Louis Pasteur discovered a way to prevent the disease from causing the death of one who has been bitten or infected if treatment is begun in time, so that the disease has lost some of its fearfulness to human beings.

The French people have built a school and hospital called the Institut Pasteur, in honor of Louis

Pasteur, and here people from all parts of the world may go for treatment. Men and women are also taught in this Institute how to treat this and other diseases of animals and man caused by bacteria and other parasites, so that they may go to other cities and lands to help the sick.

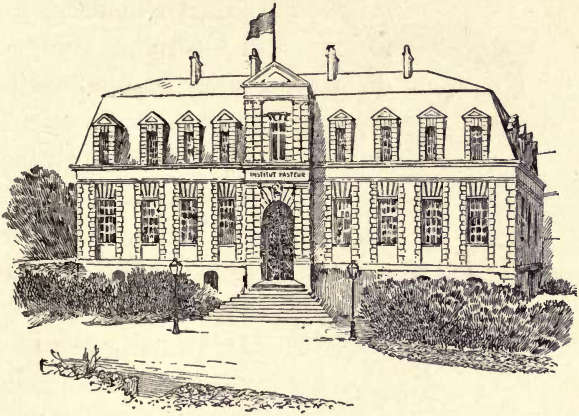


FIG. 324. THE PASTEUR INSTITUTE IN PARIS

Consumption, or tuberculosis, is one of the most terrible diseases of animals and man. This disease is also caused by bacteria. The bacteria of consumption get into the body through the nose or mouth with the air or food, or through the skin which has become broken in some way. These bacteria do not grow in sunlight or in very dry places, but they can live for several years in earth and dust where cattle are kept, or in the spittle of consumptives, or in dark, damp houses where people sick with consumption have lived.

Once inside, the bacteria of tuberculosis may grow in almost any part of the body. When they grow in the lungs, we say the person or animal has consumption, and consumption causes most of the deaths among domestic animals and men. When the bacteria of tuberculosis get into the bones, these become deformed, and the animal or person diseased becomes lame and crippled. These bacteria may get into the coverings of the spinal cord and brain and thus cause great suffering and usually death. The skin, kidneys, intestine, and other parts of the body may also become diseased, and if one part is diseased the blood is likely to carry the bacteria to all the other parts of the body as well.

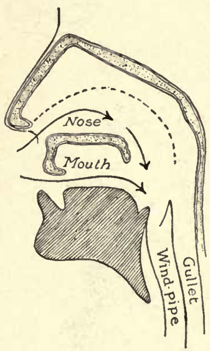


FIG. 325. BACTERIA GET INTO THE BODY THROUGH THE MOUTH AND NOSE

The kind of consumption-bacteria which live in fish and frogs and birds cannot live in man. But those which live in cattle and pigs can do so and often cause disease in man. About twenty-five out of every hundred cows have tuberculosis, and frequently ten out of every hundred quarts of city milk contain the bacteria. It is said that these bacteria can live in butter for three months, so it is easily understood how they can be taken into the human body. But doctors think that such bacteria do not cause so much sickness among human

beings as those which come from other diseased people.

Still, since we cannot be certain about the absence of danger, all cows should be carefully examined, so that our butter and milk may be free from bacteria. This is now done in many places, and sick animals are either separated from the healthful ones or killed and destroyed. No certain cure for tuberculosis has been found. The safest and best way to lessen the disease is to prevent the bacteria from entering the body of a person or of an animal. Clean, fresh air, sunlight, and good food help the body to keep free from bacteria.

FIG. 326. A BOY CRIPPLED BY BACTERIA OF CONSUMPTION IN THE BONES

More terrible than tuberculosis even, are diseases caused in human beings by bacteria which get into the organs that carry the cells which are set aside to form new living beings. Such bacteria injure these cells so that the children which grow from them are diseased when they are born or become diseased early in their lives. When these diseased children grow up, their children also become diseased

and weak, and must often be cared for in asylums or poorhouses. The brain, spinal cord, and nerves of any person suffering from a disease caused by these bacteria may become weak or diseased so that the person cannot think or work well. Often such sick people must be cared for in hospitals, and can be cured or made well again only by very good doctors.

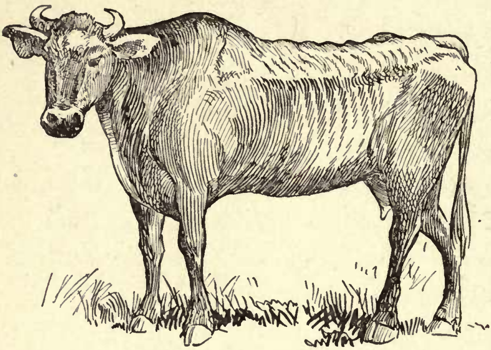


FIG. 327. A COW VERY SICK WITH TUBERCULOSIS

The bacteria that cause these terrible diseases cannot get into the body if all parts of the body are kept clean and healthful and never permitted to touch people who are sick with these bacteria, or to touch things used by them, such as drinking-cups, wash-basins, bathtubs, towels, or pencils.

Cholera and catarrh are other diseases of animals caused by bacteria. These diseases can be prevented by keeping the animals warm and clean and by feeding them clean food. Not only is it wrong not to give animals care and kind treatment, but carelessness in the treatment of animals often leads to very serious harm to human beings.

Worm parasites, such as the tapeworm and trichina, also cause disease among animals. These parasites enter the body with the food and drink, and then live in the intestine or in the muscles from which they take nourishment. If an animal or a human being has such parasites, a doctor should be asked to try to remove them at once, and all meat thought to contain the young of such parasites should be destroyed.

a FIG. 328. *b*

a. The appearance of clean milk.
b. Milk in which are many bacteria.

CHAPTER XXIII

SOME LESSONS FOR BOYS AND GIRLS FROM PLANT AND ANIMAL LIFE

WE have learned that all living things are either plants or animals. Plants and animals are made of the same kind of living substance. This living substance forms the necessary parts of a plant, like leaves, branches, roots, flower and fruit, and from it also are formed all the parts of an animal's body, such as skin, teeth, hair, eyes, ears, fingers and toes, lungs, heart, stomach, and brain. Some plants and animals are very small and made of only one undivided bit of living substance; while other animals and plants may be made of thousands upon thousands of parts of living substance joined together to make one whole, in some such way as bricks are put together to make a house. The smallest part of an animal or plant that can under certain conditions live by itself is called a *cell*.

Whether the cell is free or joined to other cells it must have food and water and oxygen and a chance to get rid of waste matters. The living substance of a cell is sensitive to heat and cold. If it gets too warm or too cold, it dies. Plant and animal cells may be killed by freezing, and they are

also killed by boiling or by becoming too heated in some other way.

When the cells of a plant or animal are healthful, the whole animal or plant is also in good health. When a plant or animal is sick, therefore, it means that some of the cells have become diseased, or that the cells are unable for some reason to carry on their work. For every living cell in a plant or in an animal has some work to do. Some cells work to prepare food for all the other cells in the plant or animal; others help to protect the body. In most animals there are cells which receive messages from the outside world, and still others help all the parts of the body to act together as if there were only one part.

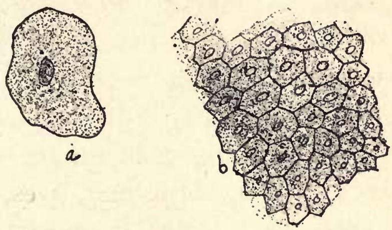


FIG. 329.

a. A single cell. *b.* Many cells together may build a body in some such way as bricks build a house.

Some cells are set aside and nourished by the other cells of the body to form new plants or animals. Such cells are very important because the continued life of animals and plants depends upon them. The cells from which new plants and animals grow are the reproductive cells, and you have learned that they are often called eggs and sperms. If these reproductive cells were injured or destroyed, most living things would soon disappear from the earth.

So you see that Nature has provided that every living thing must not only grow and care for itself, but that it is also expected to give of itself to other living things. This is one of the great rules of life.

Every living thing begins life as a cell. Some living things never have more than one cell in their body. But most many-celled animals and plants

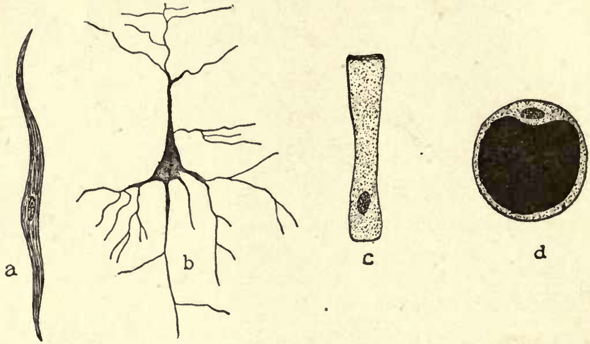


FIG. 330. VARIOUS KINDS OF CELLS
a. Muscle cell. *b.* Nerve cell. *c.* Pavement protective cell. *d.* Fat cell.

come from a cell which has been formed by the union of an egg cell and a sperm cell.

Since the cell which is to form a new plant or animal is so important, it is usually very well protected by other cells. In some cases it is sent out from the body of its parent to grow by itself outside, as in the spores of mosses and ferns and the eggs of frogs and fish. But sometimes the mother keeps the egg cell inside her own body until it has grown into a new little plant, as in the pine and rose; or into a new little animal, as in the rabbit and dog.

Plants that are closely related to each other, like the rose and the apple tree, grow in very much the same way; and animals that are related look very much alike before they are born. When the new plant or animal grows up it is seen to look very

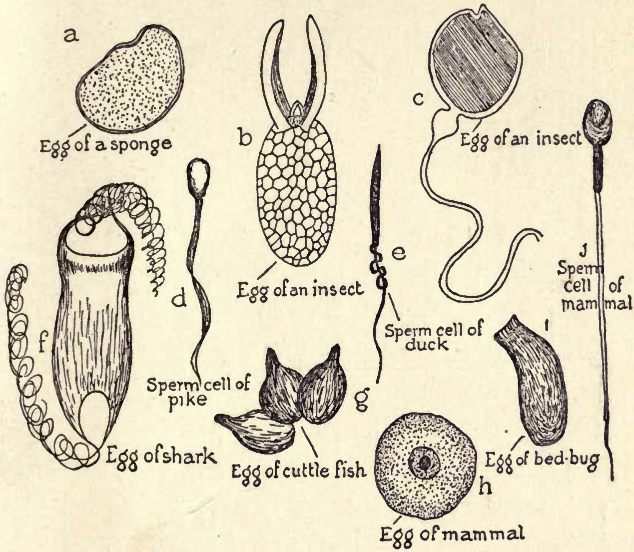


FIG. 331. VARIOUS FORMS OF EGGS AND SPERMS

much like its parents. The leaves of a new little oak look like the leaves of its mother and father oak; the little robin looks much like its parents. So, too, every oak changes from a cell to a full-grown oak in just the same way; and every robin changes from its cell in the egg to a full-grown robin just as every other robin does.

If a plant is diseased or weak, its children are

likely to be weak or to become weak and diseased. This is so well known that farmers always try to get good, healthful seed-grain for their fields, and

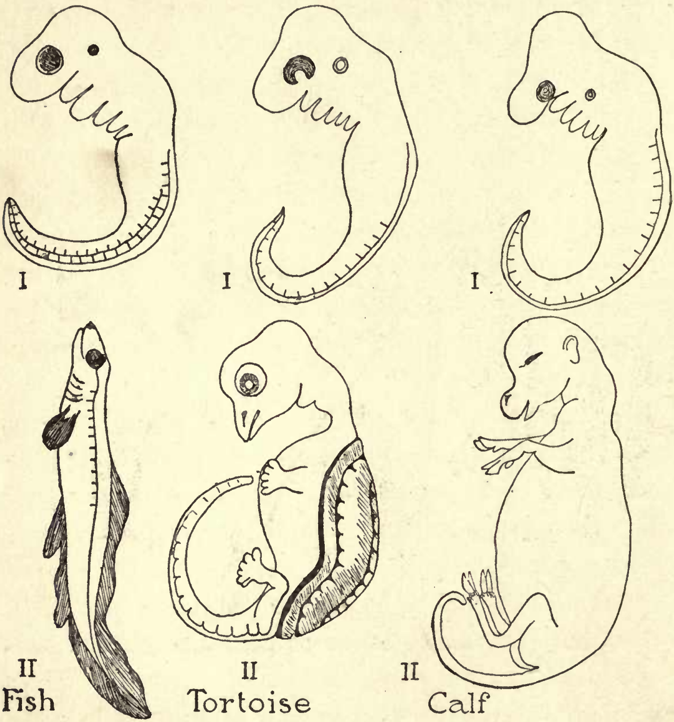


FIG. 332. THE YOUNG OF DIFFERENT ANIMALS LOOK VERY MUCH ALIKE AT FIRST

It is thought that animals looking most alike are most closely related.

only healthful, strong, well-formed horses, cattle, or sheep. If a plant or an animal is deformed or crippled in any way, it means that this animal or plant is or has been diseased or injured; or that

one or both of its parents were diseased or crippled. Even the grandchildren of diseased parents may become weak or crippled or diseased. This is another of Nature's rules and no more to be escaped than the rule of growth.

Nature's rules hold good for human beings as well as for plants and animals. The human body is also built up of cells, all of which have some special work to do. The human being grows from a cell just as plants and animals do. If the bodies of human fathers and mothers are diseased, or if their bodies are weakened in any way, their children's bodies are likely also to be weak, and weak bodies very easily become diseased.

Since every boy or girl may sometime become a father or a mother, it is very important that they keep their bodies strong and well and never at any time do anything that is likely to weaken them or to cause disease.

One who strikes or injures in any way the body of another is usually severely punished for it, perhaps locked up in prison, and said to be very wicked and bad. But a boy or a girl may cause much more pain and suffering by being careless of his or her own health or by abusing the body than does one who strikes another person. Whoever gets a contagious or infectious disease may, by giving it to others, cause the death of many. One milkman in one of our large cities, who had typhoid fever, caused four hundred other people to suffer from this disease.

There is one infectious disease which is inherited by children from their parents; and when the diseased children grow up their children inherit the same disease. In this way very, very many may be made to suffer from the carelessness, ignorance or selfishness of one person.

Infectious diseases are caused by bacteria. Many of the kinds of bacteria that cause sickness in animals also cause sickness in human beings. Bacteria,

FIG. 333. DISEASE-PRODUCING BACTERIA
a. Pneumonia and colds. *b.* Catarrh. *c.* Influenza.
d. Diphtheria. *e.* Tetanus or Lock-jaw.

one-celled animals, worms, and other parasites are usually to be found in the air, the water, or food that human beings use, and so get into their bodies.

The bacteria of consumption make thousands upon thousands of people sick every year, and a large number of those who become sick die. The bacteria of typhoid fever can live for some time in drinking-water, in milk, or in the surface of the earth. But they usually get into some person's body soon after leaving the body of another whom they have made sick. Once inside the body, these bacteria are hard to get rid of, and may live in the intestine for many years. These bacteria are often carried on the feet of flies and placed on our bread or in

our milk when the flies are permitted to come into our houses.

Typhoid fever causes the death of many every year, and those who recover from it may become lame, or crippled, or suffer in other ways all their lives as a result of it.

To prevent typhoid bacteria from getting into the body one should be careful to destroy all waste from the human body and not permit it to be thrown into rivers, lakes, or streams, the water of which might be used to drink or to wash water-pails or milk-pails. One should also try to destroy flies and their breeding places. One should be cautious about drinking water from shallow wells, springs or streams. More people suffer from typhoid fever in the country than in the city because water is so often taken from shallow wells into which the bacteria come from the surface of the earth or from waste matter near by. Very clean looking and sweet tasting water may contain typhoid bacteria, so that drinking-water from a well ought to be examined for bacteria before it is used.

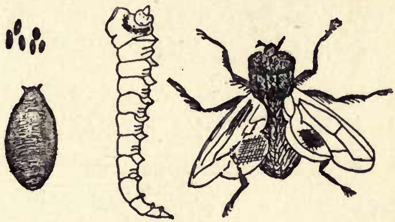


FIG. 334. THE HOUSE-FLY AND ITS EGGS AND YOUNG

Many hundred thousand babies die every year, especially in the summer, when their bodies are weakened by the heat. This is because bacteria

get into their bodies with the milk or water they drink. Most of the sickness and death among babies could be prevented if the food given them was clean and fresh. Milk-bottles and milk-jars should be scalded with hot water so that any germs in them may be killed. A baby should be kept as cool and as quiet as possible in summer, and should be kept away from dust and dirt.

Whooping-cough, colds, and diphtheria are all caused by bacteria, and these diseases are all infectious, and persons who are sick should not be permitted to remain in the same room with those who are well. Sore eyes are also caused by bacteria, and therefore no one should use towels or wash-basins in public places like railway stations or restaurants, and every pupil in school should have a towel for individual use.

Pencils may carry germs of various kinds, and so pencils should never be put into the mouth. Pieces of silver or copper money which pass through so many hands may also be covered with bacteria. Putting objects other than food into the mouth is a bad habit and very often dangerous.

Bacteria may also get into the body through the reproductive organs and cause disease in these and in all parts of the body. Therefore these organs should be kept just as clean as all other parts of the body, and nothing unclean or diseased be permitted to touch them. More suffering and misery are caused by such bacteria than by any other kind, and one

of the diseases they cause is inherited by the children of those who are diseased.

Small-pox, scarlet fever, malarial fever, measles, and chicken-pox are thought to be caused by tiny one-celled animals and not by bacteria.

Hook-worms, tape-worms, and pin-worms live in the intestine of people and cause serious sickness, but not so often death as do the bacteria and one-celled animals.

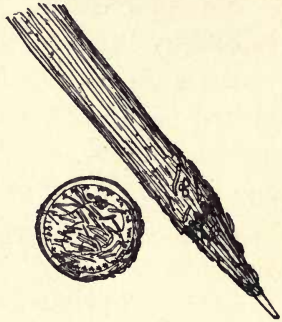


FIG. 335. PENCILS AND COINS MAY BE COVERED WITH BACTERIA

The best way to prevent any parasite from causing sickness is to keep well and strong. There are a few simple rules which help one to keep strong. One must eat nourishing food—not too much of it, nor too little. The food and water taken into the body must be free from parasites of any kind. The body should be kept comfortably warm, and one should avoid touching waste-matters or breathing dusty air. One should have plenty of work to do. A person who does not work soon becomes weak, and then the parasites easily keep themselves alive within the body. One should also have pleasant play-times; for it is not well to work all the time of the day. And lastly, one should have plenty of sleep in a room supplied with pure air. Whenever it is convenient it is well to sleep out of doors. Pure

air kills some bacteria, and sunlight kills others. The body should always be kept clean. It is well to take a bath every day.

If cleanliness, good food, and good air can be had, and if the mind and the hands are kept busy with some useful work, there is not much danger from bacteria or any other parasites.

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